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Utilization of bullock energy by using rotary mode power transmission system in operating agro-processing unit (Sevai machine)

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Abstract
In rural areas electricity is either unavailable or available for limited period. So performing many activities with the help of animal driven rotary mode power can be a good alternative.
The bullocks can be used in rotary mode power transmission system, post-harvest operations like mini rice mill, flour milling, chaff cutting, dal milling, groundnut decortications, oil extraction, threshing Shevai making machine and other stationery operations. Draught animals are used for a limited period for agricultural work 40 to 50 days and the rest of the time they stand idle. The farmer has to feed them throughout the year despite no work output during off season, leading to high maintenance cost as compared to power output. But this idle period can be utilized and converted to work through rotary mode operation. The proposed research work presents the performance evaluation of shevai machine unit. The mean draft was 418.1N which was 4.84 per cent of bodyweight of the bullocks. The increase in respiration rate, pulse rate decreased with duration. The rpm of bullock from 30 min. of trials was initially 65 and reduced to 60 at load condition. The mean rpm of the shevai machine shaft was observed to be 150. The output of machine gradually decreased with duration may be due to a decrease in the speed of the shaft of the shevai machine. The mean output was found to be 8 kg/h were as the output of shevai machine operated with an electric motor was 10 kg/h. The average power output from the bullock over three times 30 minutes of working in Shevai machine was 0.498Kw. The operation of the Shevai machine was found to be feasible considering the draft ability of Red Kandhari type bullocks. The total cost of operation of unit was calculated Rs. 8.33 Rs / h with an output capacity of flour mill observed 1.0 hp.

Keywords: Shevai machine, red Kandhari bullock, draft, pulse rate, percentage body weight, power output, machine rpm

Introduction
Drought animals will continue to be used in Indian agriculture which is time tested renewable source dwindling reserve of non- renewable source of energy (Yadav 2001) it is estimated that agro processing sector used about 10 per cent of their total energy available in the country as compared to 7 per cent in 1980-81, this additional demand has to be met through electrical mechanical/ animal power. It is estimated that liquid fuel and natural gas would be exhausted by 2050 and coal by 2250 at the present rate of use. The average annual utilization of bullock hrs. in agriculture in marathwada region was found to around 500 hrs./ year in rain fed agriculture and around 900 hrs./ year in double season irrigated area as against and estimated potential of about 2400 hrs./years.
The rotary mode can serve as a prime mower. This may be beneficial to animal owners of remote rural areas, when it can be used to enhance the utility of animals, thereby, reducing maintenance cost. The savings in the use of commercial sources of power in the present era of escalating fuel prices. Pollution free energy is the added advantage of the system. Using animal power for operating small capacity agro processing machines in rotary mode is the solution without the use of electric motor or IC engines in remote villages in hills or plain areas where either the electric supply is not regular or erratic. For this purpose, a Chaff cutter was identified and modified for rotary mode of operation. Similarly a Multi-crop plot thresher and a Mini dal mill were identified further modified for rotary transmission system. The cost of utilization is therefore, very high as the bullocks are to be fed throughout the year whether they are in use or not and thus to reduce the economic burden of owning a pair of the bullock is to increase the utilization of annual hours of the bullock.

Considering the limiting power of a pair of a bullock (1hp), the animal power for operating small capacity agro processing machines operating in rotary mode was designed and fabricated.

Materials and Methods

Experimental Set- up

The experimental set-up consisted of an outdoor test track, test bullocks, yoke, rotary power transmission system, underground shaft, output shaft and v pulleys, Agro-Processing Machineries etc.

Selection of animals

Two healthy bullocks were selected for the study. In selecting the animals, more emphasis was given on the body weight rather than the age of the animals. A pair of test bullocks in the age group of 7-8 years of local breed was used for the experiments. The total weight of bullock pair was 900kg. The accuracy and quality of work performed by an animal depends upon training, regular practice and effective guidance. The test bullocks were reluctant to operate in rotary motion initially, they reacted adversely and it became very difficult to handle them. Therefore, they had to be trained by a very skilled stockman or operator under whom they could be controlled. Trainers used a stick lightly on their hindquarters to encourage them to follow the correct path until they became familiar with it. The coordination between their walking speeds was also very poor initially because the inner bullock has to walk slower as compared to the outer bullock. The path followed was also not a perfect circle. Many times they wanted to get rid of the yoke. During the first fifteen days, the experimental bullocks generally groaned and slavered as they worked. After training the bullocks became accustomed to the pattern of the experiment and their strange behavior was largely disappeared. The bullocks were fed fodder and feed daily as per recommended practice. The health of the animal pair was good throughout the experimental period.

Test track

Test track was a circular piece of land of 5.50 m radius. The soil was well compacted leveled and cleaned to remove any stone in the path of the bullocks. The entire track was raised by (10) cm from adjacent land. The gear unit of the developed power transmission unit was mounted on an MS angle frame firmly grouted by cement concrete mortar with studs at the centre of the test track.

Power Transmission System

The power transmission system converts the animal muscle power to mechanical energy. It mainly consisted of a horizontal hitch beam, gearbox, shafts and pulleys. The gearbox was installed at the centre of the test track. The different components of the unit are described below:

Beam

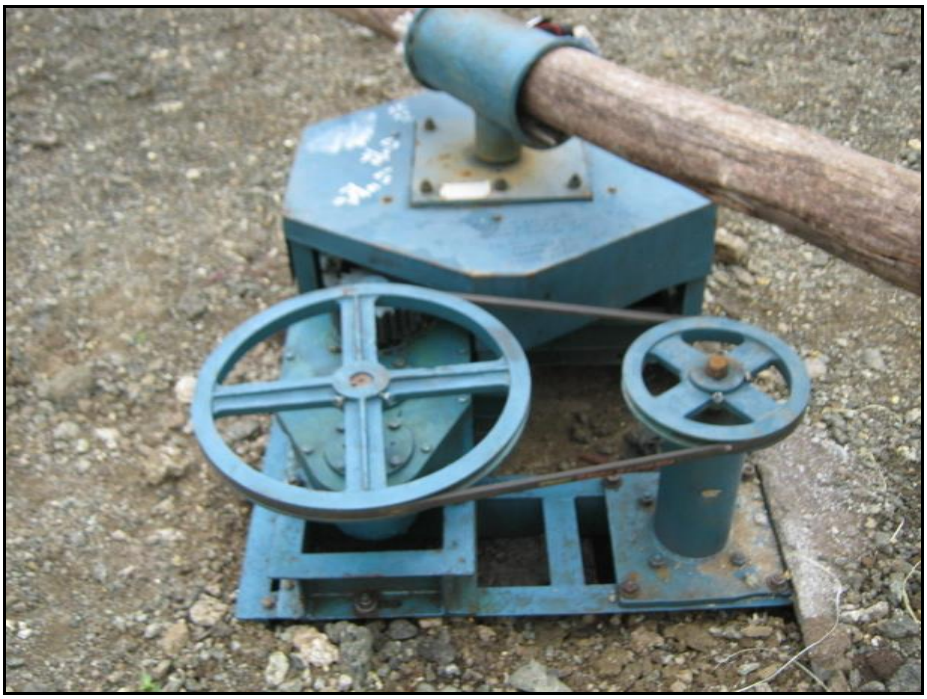
A wooden beam of 127.2 mm diameter and 5.0 m length were used as input shaft of the power transmission system to give drive to the gear box through animal power.

Power transmission unit

As per the literature available, the speed requirement for operating different agro processing units is between 100-1000 rpm. Accordingly various combinations of pulleys were selected to raise the slow moving speed of animals (average 2 rpm) in the range of 1000-1200 rpm required to operate low speed agro processing units.

Gear unit

As per the literature available, the speed requirement for small capacity agro processing machines operating is in between 800-1000 rpm. Accordingly various combinations of spur gear, bevel gear and pulleys were selected to raise the slow moving speed of animals (average 2rpm) in the range of 1000-1200 rpm required to operate small capacity agro processing machines.



Installation of Animal driven rotary Power Transmission unit

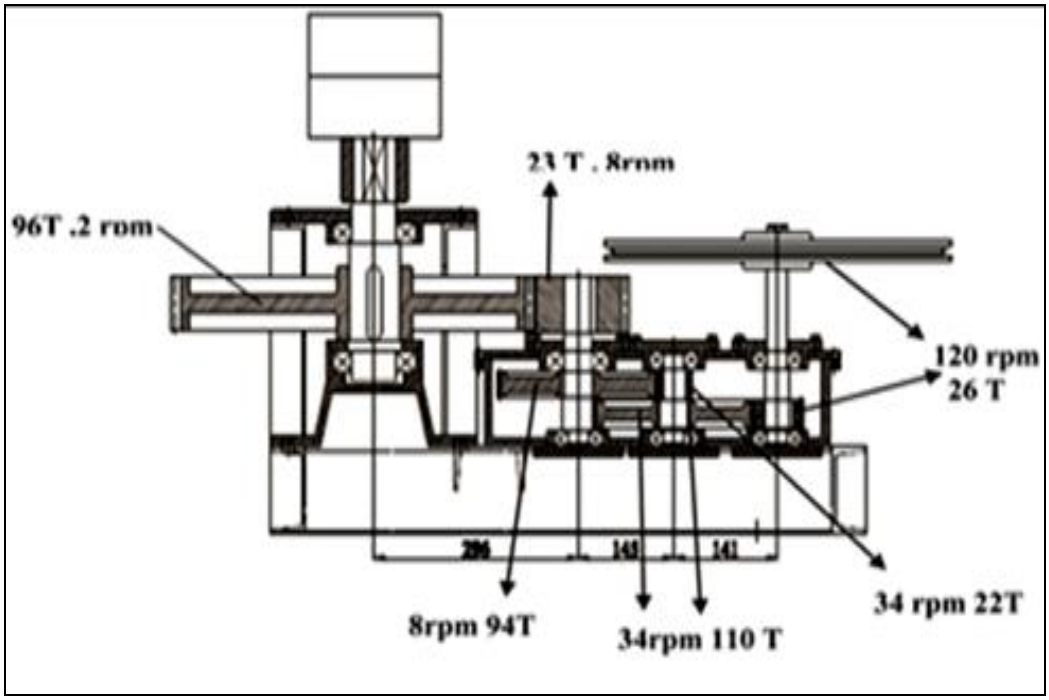


Fig 1: Side View of Power Transmission Unit

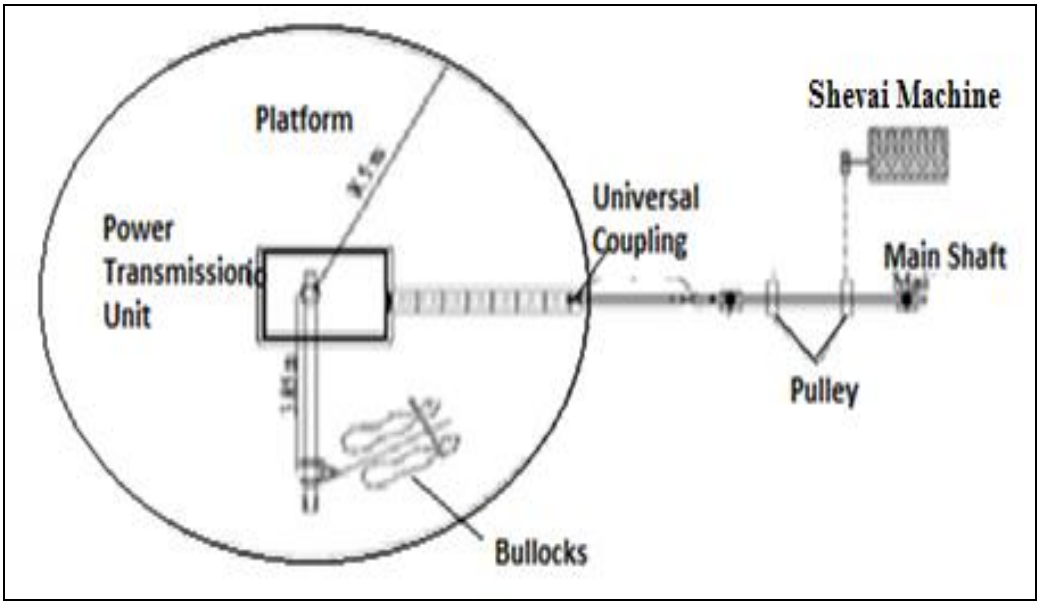


Fig 2: Top View of Rotary Mode Agro –Processing Unit

Work performance

Draft

Pull is measured with the help of a dynamometer attached between yoke and beam. Draft was calculated from the multiplication of pull into angle made by animal with the direction of travel.

$$D = P \times \cos \emptyset$$

Where,
D = Draft in kgf
P = Pull in kgf
Ø = Angle between line of pull and horizontal

Speed

Speed is calculated with the help of following formula:

$$S = \frac{L}{T} \times 3.6$$

Where,
S = Speed in km/hr
L = Distance moved or traveled in meter
T = Time required by the bullock to travel certain distance in Second
3.6 = Conversion factor for km/hr

Horse power

Horse power is the multiplication of draft and speed. Values of the horse power computed as per Broody (1945) from equation,

$$\text{Horse Power (hp)} = \frac{D \times S}{75}$$

Where,
D = Draft developed, kg
S = Speed of bullock, m/s

Experimental Procedure
Experiments were conducted at AICRP on Utilization of Animal Energy site, CAET, VNMA University Parbhani. The procedure followed is described below:

Evaluation of power transmission system
The developed power transmission system was evaluated by computing the power, draft and output. The load was applied only after the bullocks attained the desired working speed.
The dynamometer was mounted between yoke and beam, such that the pull exerted by the bullocks was applied to the beam through the dynamometer and which showed the instantaneous pull acting at the beam. The recorded draught was used to calculate input power.
Test bullocks were hitched and allowed to move on a circular track. The system was tested at no load and loads. The resulted draft was measured using dynamometer. The input power was calculated using the following relations:

$$Input\ Power\ (kW) = \frac{Draft\ (N) \times Speed\ (m/s)}{1000}$$

Physiological Responses of Bullocks
The trials were conducted using yoke. Tests were conducted during summer (March-April) season. Trials were conducted using following schedule.
0.5 work + 1h rest + 0.5 work+ 1 h rest + 0.5 work
During the rest period animals were kept in shed and also given feed and water. The environmental temperature started declining in the evening session and animals work up till the natural light was available. Hence, on an average the animals worked for 3-4 hour per day.
The physiological responses such as respiration rate, pulse rate and body temperature were recorded at the start of work in both the sessions termed as initial values. Then, after every half hour of work the observation were recorded for physiological responses and physical symptoms for both the bullocks separately. The bullock moving in the outer circle was termed as outer bullock and the one moving inside was called inner bullock. The average speed was also calculated.

Performance of selected Agro Processing Unit

Table 1: Selected Agro-Processing Machine rpm Record

Sr. No.	Machine	Electrical rpm with 1.0 Hp Motor	Rated rpm with Bullock Operating (Power Transmission unit)
1	Shevai Machine	150	160

For shevai machine Electrical rpm was 150 measured by Tachometer and the Rated rpm with Bullock operating Power Transmission unit rpm 160 was measured. For obtaining the same rpm, 10 cm pulley mounted on the counter shaft was connected through v- belt with shevai unit 17.5 cm pulley with step down ratio 1:0.57 so for shevai machine the final speed ratios at shevai unit 1: 0.4.

Evaluation of Shevai machine
The Shevai machine of capacity 1 hp model No. Shevai 60 manufactured by, Mahila Udyog Machinery, Akola was modified and used in animal driven rotary transmission system. An output capacity in Kg per hour was measured in respect of animal and electric operated. The output capacity of Shevai machine operated by animal driven rotary transmission system was also compared with an electric operated Shevai machine of capacity 1 hp respectively. In this machine different size Shevai plates can be used for different thickness of Noodles or Shevai strings.

Table 2: Specification of Shevai machine

Sr. No	Overall Dimensions of Shevai machine	
1	Length (mm)	1260
2	Width (mm)	470
3	Height (mm)	900
4	Weight (kg)	70
5	Number of sieves plate:	01
6	Working efficiency (per cent)	95.2-90.1
7	Power requirement (kW) :	4.3-5.7
8	Capacity (kg/h) :	8-10

Results and Discussion
The developed power transmission system was evaluated for its performance for selected agro-processing units. During the test, bullocks were hitched at a distance of 5.5 m from the centre of vertical input shaft. The bullocks walked in circular motion that resulted on an average 2.0 rpm at vertical input shaft and 780,358,330,316,285,152 rpm at pulleys of flour mill, chilly mill, grain polisher, seed cleaner cum grander, papad machine and shevai machine counter shaft. These units of 1 hp capacity were operated by the power transmission system. The speed (kmph), draft (kg), Output (kg/h), Power developed (W), physiological responses experimental bullocks in various agro processing operations were recorded.

Performance Evaluation for Operating Selected Agro Processing Units
The comparative physiological behavior of inner and outer bullock (B1 & B2) in rotary mode of operation for agro processing units were observed. The test was carried out on the test track for continues half an hour of work duration. Selected Agro-Processing Machine was used for operation by using bullock power in rotary mode of operation.
The selected agro-processing machine can otherwise be operated with a 1 hp motor. The experiment was conducted continuously for 30 minutes with the measurement of physiological responses like respiration rate, pulse rate, body temperature of red kandhari breed of bullock (pair weight of bullocks is 880 kg.) of Maharashtra at half an hour interval and calculation of draft to know their comfortable working without inflicting any health hazards One person was employed for work in the selected agro-processing machine and one bullock operator was engaged for controlling a pair of bullocks in the test track of rotary unit. The Standard technique was used for measurement of the different parameters. The experiment was conducted for three replications of 30 minutes following observation were taken at half an hour.

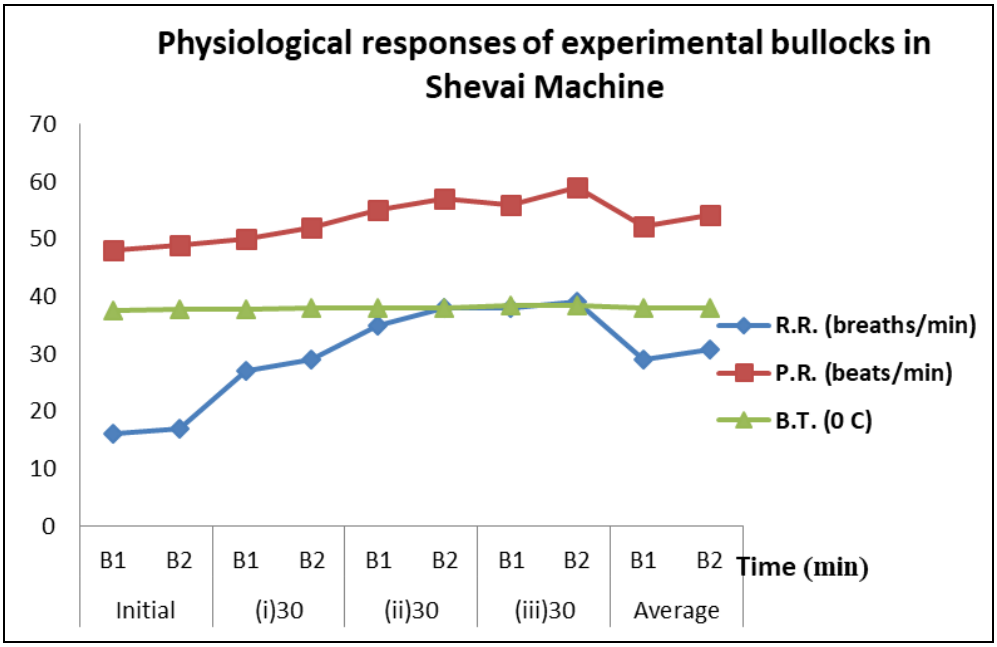
Rotary Gear Parameter
- Power transmission system.
- Gear ratios at various units of the rotary system

Bullock Parameter both at Load Condition
- Speed of bullock
- Average draft
- Power output
- Physiological responses

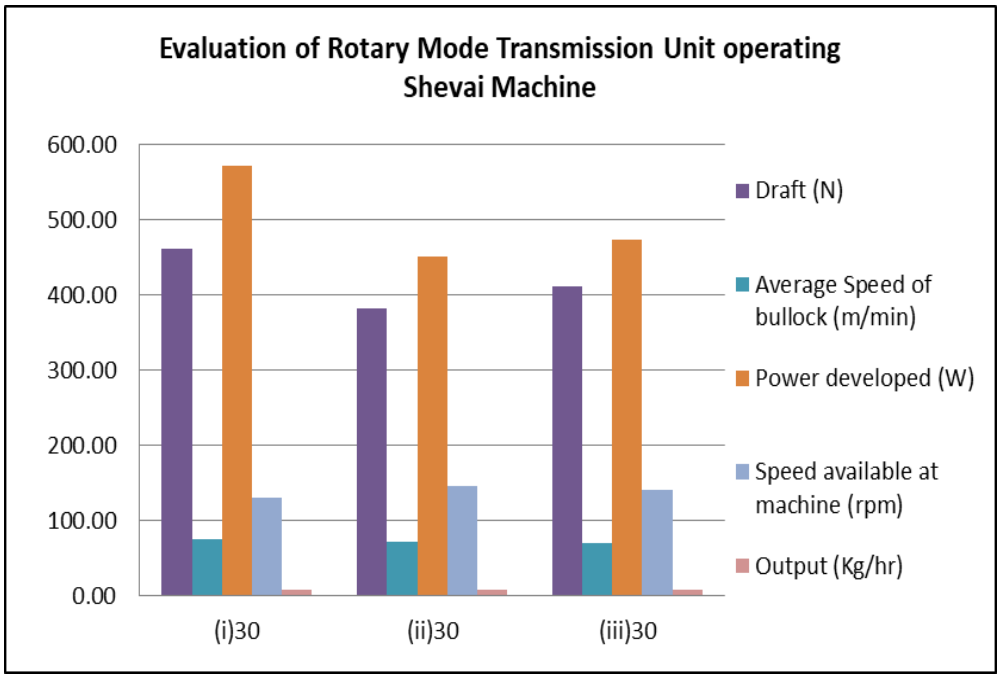
Machine Parameter
- rpm of shaft of the machine
- working efficiency per cent

Cost of Operation
The cost of operation was calculated for operation agro-processing machine in the rotary mode of operation through bullocks and compared with electrically operated motor. Variable cost for selected machine one person and one bullock operator with labor charge. Rs. 150/ day of 8h / person.

Performance Evaluation of Shevai Machine operated at load condition
The data on the performance evaluation of shevai machine in rotary mode has been presented in table No.5.5.2 the draft requirement varied 460.6 N in the beginning to 382.2 N at the end. The mean draft was 418.1N which was 4.84 per cent of bodyweight of the bullocks. The increase in respiration rate, pulse rate decreased with duration. The mean respiration rate, pulse rate, body temperature of B1 and B2 were found to be 26.5 and 28.5 bpm, 51.00and 52.5 bpm, 37.45 and 37.62 ^{o}c respectively. The rpm of bullock from 30 min. of trials was initially 65 and reduced to 60 at load condition.



Graph 1: Physiological Responses of Experimental Bullock In Shevai Machine



Graph 2: Evaluation of Rotary Mode Transmission system for Shevai

Machine

The mean rpm of the shevai machine shaft was observed to be 150. The output of the machine gradually decreased with duration may be due to decrease in the speed of shaft of the shevai machine. The mean output was found to be 8 kg/h were as the output of shevai machine operated with electric motor was 10 kg/h. The average power output from the bullock over three time 30 minutes of working in Shevai machine was 0.498Kw.This indicated that the bullock could easily do the operation and their utilization could be enhanced. The lower value of working efficiency may be attributed due to the non uniform speed of bullocks during the working of the shevai machine. The operation of shevai machine was found to be feasible considering the draft ability of Red Kandhari bullocks and their output capacity.

Table 3: Performance of Shevai machine in rotary mode of operation at load condition

Parameters	Duration, h								Mean	
	In		0.5		1.0		1.5			
	B1	B2	B1	B2	B1	B2	B1	B2	B1	B2
Respiration rate, bpm	16	17	27	29	35	38	38	39	26.5	28.5
pulse rate, bpm	48	49	50	52	55	57	57	59	51	52.5
Body temp, ^{0}C	37.6	37.7	37.7	37.9	37.8	37.9	38.5	38.5	37.45	37.62
Draft, kg	_		47		39		42		42.66	
Percentage body weight	_		5.34		4.43		4.77		4.84	
Draft, N	_		460.6		382.2		411.6		418.13	
rpm of bullocks/0.5h	_		65		62		60		62.33	
Speed, m/s	_		1.24		1.18		1.15		1.19	
Speed, km/h	_		4.46		4.24		4.28		4.32	
rpm at m/c shaft	_		138		160		150		150	
rpm at Rack- Pinion shaft	-		67		79		74		73.33	
Power output from Bullock (kW)	_		0.571		0.450		0.473		0.498	
Output(Kg/h)			7.5		9.0		7.0		7.83	

Shevai Obtained from Bullock Operated Power Transmission System

Conclusions

It is observed that the selected gadget i.e. Shevai Machine can be operated on bullock power with the rotary mode.

The power output and the speed are mainly dependent on draft of animal and all three are interrelated among themselves.

Bullocks can operate 1.5 hours continuously all the selected gadeget without fatigue. The output of selected gadget i.e Shevai Machine is 8 kg /hr respectively.

The ideal period of draught animals can be efficiently utilized and annual use can be increased by operating small post harvest machine like Shevai Machine.

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