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Development and performance evaluation of a feed-in type sunflower thresher operated by bullock power in rotary mode

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ABSTRACT

In Odisha, the small and marginal farmers in many districts still depend upon the animal energy for accomplishment of agricultural operations because of small and fragmented land holding as well as poor socio-economic status. Of late, the maintenance cost of a pair of bullocks proves to be a burden on these farmers with increase in labour cost. A study on use of animal energy for operating a feed-in type sunflower thresher with rotary gear system was made to increase the output against the conventional manual method using threshing bench and also to increase the annual use of the bullocks so as to reduce the owning cost of bullocks.The results on operation of thresher indicated that the average output of the thresher was 66.98 kg h^{-1} with mean threshing efficiency of 93.65 per cent. The mean draft was 484 N which was 7.9 per cent of the bodyweight of the bullocks indicating that the thresher can be comfortably operated by a pair of bullocks in rotary mode. The cost of operation of the thresher in rotary mode was found rather economical compared to threshing by manual method using threshing bench. The use of sunflower thresher in rotary mode will increase the annual utilization of animal and can save time in threshing, reduce drudgery in operation compared to traditional manual threshing bench method.

Keywords : Bodyweight, draft requirement, output, rotary gear system, threshing efficiency.

Sunflower (*Helianthus annuus* L.) is one of the world's most important oilseed crops. Sunflower oil is popular as healthy cooking oil due to its health benefits *i.e.* high in the essential vitamin E and low in saturated fat (Downey *et al*., 1989). As such, the oil content of sunflower is 40-50 per cent, which is higher than any other oilseed crops (Rizvi *et al.*, 1993). The world sunflower seed production stood at 32.39 million tonnes from an area of 23.71 million hectares, accounting for 8.5 per cent of the total oilseeds production, while India contributes 8.7 per cent of the total Sunflower seed production. Sunflower is one of the fastest growing oilseed crops in India. The area, production and yield of sunflower at national level is 0.69 million ha, 0.55 million tonnes and 791 kg ha^{-1} respectively. The area, production and productivity of sunflower in Odisha are 24.88 lakh ha, 26.69 lakh MT and 1193 kg ha^{-1} respectively. Conventional method of threshing of sunflower by manual hand beating method is labour and time consuming process apart from the problems encountered in terms of damage to the seeds and existence of some un-threshed seeds which results in reduction the threshing efficiency and seeds quality. This problem obviously arises due to the nature of the seeds and their physiology. Peeneej dangang (1999) reported that the threshers designed for paddy and soybean were tested for threshing sunflower which indicated that these threshers are not appropriate for threshing sunflower, as grain damage may be as much as 4-10 per cent, cleaning efficiency only 87-92 per cent, and grain losses were as high as 20-35 per cent. The output of the sun flower threshing bench of OUAT design and manual hand rubbing method are 10 kg/man-h and 1.5 kg h^{-1} respectively (Goel *et.al.*, 2009). The hold-on type OUAT power operated sunflower thresher is yet to be accepted by the farmers because of possibility of injury to hand while threshing.

In Odisha, around 77 per cent of the farmers are under small and marginal categories, who posses about 43 per cent of the total cultivable land. In fact, the small and marginal farmers in many parts of the state of Odisha still depend upon the animal energy for accomplishment of agricultural operations because of small and fragmented land holding as well as poor socio-economic status (Anon., 2011). Use of bullocks for agricultural work is limited to tillage, threshing and transportation in the state of Orissa (Kurup, 2003). The total annual use amounts to less than 300 hours and thus their maintenance cost becomes too high for the poor small and marginal farmers (Anon., 2001). Kurchania, *et al.* (2003) reported that the utilization of bullocks can be increased if the bullocks will be used to carry out post-harvest operations of different crops with rotary gear system. Swain, *et al.* (2015) reported that use of animal energy for two post harvest operations such as paddy threshing and chaff cutting with rotary gear system was made to increase the annual use of the bullocks so as to reduce the owning cost of bullocks. It is therefore proposed to develop a feed in type sunflower thresher to be operated by bullock power in rotary mode to achieve higher output and better utilization of bullock power and also compare its performance with the existing methods of sunflower threshing.

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Table 1: Salient specifications of the multi- crop thresher.

Type	:	Axial flow
Recommended Power	:	A pair of bullocks in rotary mode per 1.0 hp
		Single phase electric motor
Type of drive	:	V-belt and pulley
Main crop	:	Sunflower
Main drive belt	:	V-Belt, C-108 (3 nos.)
Size of Pulley (mm)	:	Drive- 2" dia & Driven- 6" dia
Diameter of Main shaft (mm)	:	32
Recommended speed of main drive (rpm)	:	450- 500
Type of threshing cylinder:		Rasp bar
Diameter, (mm)	:	210
Length of cylinder, (mm)	:	405
Peripheral speed, (m sec^{-1})	:	4.95
Concave type	:	Semi-cylindrical
Recommended concave clearance, mm	:	30
Sieve type and number:		Punctured MS sheet, 2 nos
Height and location of feeding system	:	1046 mm from ground level.
		Placed at RHS of thresher
Shaker Type:		Eccentric shaft
Drive:		Through “V” belt and pulley
Blower nos and type:		One, Centrifugal type
Number of blades & Size of blades, (mm)	:	4 blades, 410 x 75 x 2 , depth- 15 mm
Crop feeding type:		Hopper feeding type
Overall dimensions, (L x W x H) mm	:	(1193 x 1124 x 1046)
Weight, (Kg)	:	180

Table 2: Assumptions for computing cost of operation

Units	Cost, (Rs)	Life span	Repair & maintenance	Annual use, (h)
Rotary unit	55000	10	5 % of the cost	960
Thresher	25000	10	-do-	240
Bullocks	20000	5	Rs$5h^{-1}$	1200

Variable cost :

Threshing: one person and one bullock operator

Local method of threshing (threshing bench):

Labour charge Rs. 200 day^{-1}

Table 3: Physiological responses of bullocks in rotary mode of operation (Feed-in type Sun flower Thresher) at no load

Parameters	Duration (hrs)							Mean
	Initial	0.5	1.0	1.5	2	2.5	3.0	
Pulse rate, (bpm)	48	51	55	62	68	77	79	65
Respiration rate, (bpm)	15	22	25	28	31	33	37	29
Body temp., (^{O}C)	38.1	38.2	38.3	38.4	38.4	38.5	38.6	38.4
Amb Temp., (^{O}C)	25.1	25.2	25.5	26.1	26.7	27.3	27.6	26.4
RH, (%)	35	36	35	35	34	33	33	34
Draft, (N)	-	212	216	217	221	223	222	219
RPM of bullocks ($0.5h^{-1}$)	-	68	64	61	58	52	50	59
Speed, (km h^{-1})	-	3.15	3.06	2.83	2.69	2.42	2.32	2.75
Power output, (kW)	-	0.25	0.25	0.23	0.22	0.20	0.23	0.23

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

Parameters	Duration(hrs)							Mean
	In	0.5	1.0	1.5	2	2.5	3.0	
Pulse rate, (bpm)	52	67	69	77	81	85	89	78
Respiration rate, (bpm)	14	25	32	36	43	48	55	40
Body temp., (^{O}C)	37.7	38.1	38.3	38.4	38.5	38.6	38.8	38.5
Amb temp., (^{O}C)	25.3	25.7	26.4	27.3	28.5	29.1	29.4	27.73
RH, (%)	35	35	34	34	33	33	31	33.33
Draft, (N)	-	518	502	485	479	463	458	484
RPM of bullocks ($0.5h^{-1}$)	-	66	64	61	56	51	44	57
Speed, km h^{-1}	-	2.49	2.41	2.30	2.11	1.94	1.67	2.15
RPM of thresher	-	470	464	449	431	419	407	380
Peripheral velocity, (ms^{-1})	-	5.17	5.10	4.94	4.74	4.61	4.48	4.84
Threshing efficiency, (%)	-	96.2	94.5	93.2	93	92.5	92.5	93.65
Output, (kg h^{-1})	-	68.8	67.4	66.8	66.6	66.6	65.7	66.98
Power output, (kW)	-	0.363	0.341	0.314	0.285	0.253	0.216	0.295
Fatigue score	-	8	8	11	12	12	13	11

Table 5: Cost economics of sunflower thresher operated in rotary system and manual threshing in threshing bench

Machine	Fixed cost, Rs. ha^{-1}	Variable cost, Rs. ha^{-1}	Total cost Rs. ha^{-1}	Total cost, Rs. q^{-1}
Rotary unit	5.0	-	-	-
Thresher	6.5	-	-	-
Threshing in rotary mode	20.4	26.25	46.65	69.65
Bullock + plough man (when used)	8.90	8.75	17.65	-
Traditional method(Threshing bench)		-	-	250*

** The output was 10 kg ha^{-1} when the threshing bench was used for manual method of threshing.*

Jadhav and Deshpande (1990) developed a pedal operated hold-on type sunflower thresher and reported that the output capacity, threshing efficiency and cleaning efficiency were about 40 kg½seed ha^{-1}, 100 per cent and 96-98 per cent, respectively. Rizvi *et al*. (1993) compared the performance of different threshing drums for sunflower threshing. The spike/peg tooth, rasp bar and rubber strip cylinder with their respective concaves were used. The study showed that the peg-type cylinder with a speed range of 400-500 rpm and a concave clearance range from 25-30 mm can be used for a sunflower threshing unit. Naravani and Panwar (1994) studied the effects of the impact mode of threshing on the threshability of a sunflower crop. The results showed that threshing efficiency increased as the impact energy increased at seed moisture contents ranging from 5.76 to 13.56 per cent (wet basis). A threshing efficiency of 71 per cent with 9.7 per cent (wet basis) seed moisture content at an energy level of 20.6 N m was observed. Bansal *et al*. (1994) evaluated different sunflower threshers. Sunflower threshers based on axial flow designs were mostly used. It was concluded that sunflower should be threshed at a cylinder speed of 6.5 ms^{-1} with a feed rate of 1500–2000 kg head ha^{-1} at a grain moisture content of 30 per cent (wet basis). Anil *et al*. (1998) designed and developed a prototype threshing machine for sunflower seeds, using basic principles adopted for cereal threshers. Test results indicated that, the optimal thresher performance was achieved at 9-13 per cent moisture content, 180 kg ha^{-1} feed rate and 500 rpm cylinder speed.

MATERIALS AND METHODS

The rotary gear unit procured from UAE centre of Allahabad was installed in the premises of College of Agricultural Engineering and Technology, OUAT, Bhubaneswar. The rotary gear unit consists of few components such as a gear box, spur gears, bevel gears,

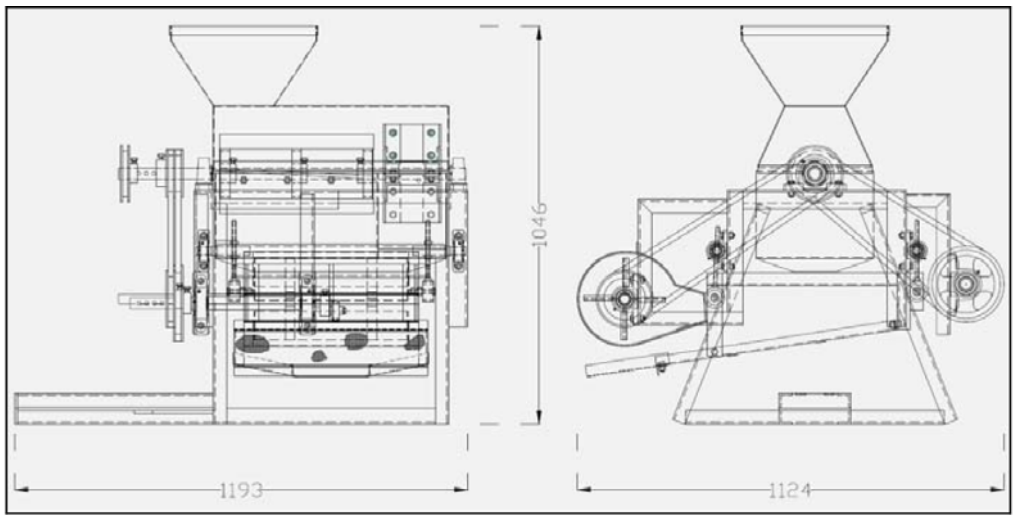

Fig. 1 : Schematic diagram of feed in type sun flower thresher

Fig. 2 : Development and evaluation of Feed in type sunflower thresher operated by bullocks in rotary mode.

shafts, bearing, bearing cover, bushes and belt pulley transmission unit. There is a set of spur gears which transmits the power between two parallel shafts. The spur gear has 77 teeth while the spur pinion has 16 teeth. The speed ratio of 1: 4.8 is obtained. Further, there is a set of bevel gears (spiral tooth bevel gear having module 6.5 mm) which has 43 teeth and bevel pinion has 7 teeth. The speed ratio is 1: 6.14. Combination of bevel and spur gear can produce the speed ratio of 1:29.56. 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 15 cm thereby stepping up the speed in the ratio 1: 4 when connected with flat belt. For threshing operation, a 35 cm pulley is also mounted on the counter shaft which is connected through belt with the thresher shaft having a 20 cm pulley stepping up the speed in the ratio 1: 1.75. So for thresher the final speed ratio is 1:210. A Ratchet assembly was developed to prevent the back flow of power to the bullocks when they stop during working. By this unit, the input shaft from the bullocks stops rotating when the bullocks stop moving; but the gear unit and the connected shafts keep on rotating due to their inertia (Anonymous, 2011).

Development of feed-in type sunflower thresher

A feed-in type sun flower thresher to be operated by bullock power in rotary mode was developed, consisting of a threshing cylinder, an oscillating screen and a blower (Fig.1). The thresher cylinder shaft gets drive from the bullock operated rotary system while the oscillating screen and the blower are attached to the thresher shaft by belt and pulley system. The matured and dried whole sun flowers are put in to the hopper which is threshed in the cylinder to separate the sun flower seeds to fall on the oscillating screen while the blower is used to clean the threshed seeds. The sunflower threshing unit operates on the principle of axial flow movement of the material. The threshing mechanism consisted of a rasp bar type threshing drum, which rotates inside a two section

concave. The cylinder of length 405 mm has two portions; the first one of 285 mm is for threshing and the second one of 120 mm for threshed sun flower head throwing. The threshing portion has raised spikes. The concave was made of mild steel rod of 10 mm diameter having distance between adjacent rods as 10 mm, and between the rod axes as 22 mm. The cylinder-concave clearance is 30 mm and is uniform throughout its length. It consists of a feed hopper, bar type cylinder, thrower, two sieves, concave and a blower. It works on axial flow principle. The threshing portion has straight flats. The cylinder-concave clearance is 30 mm and is uniform throughout its length. The cylinder is hexagonal in shape. The cleaning system consists of a centrifugal blower and an oscillating screen with circular holes of 20 mm diameter and 25 mm centre to centre distance between holes. The specifications of the developed feed in type sunflower thresher to be operated by bullock power in rotary mode have been presented below.

The thresher was run with the bullocks in rotary mode of operation and one person was employed for feeding during threshing operation. 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 no load
Power requirement at load

Bullock parameters both at no load and load condition

Speed of bullocks
Average draft
Power output
Physiological responses
Fatigue score

Machine parameters (Thresher)

Peripheral speed of thresher
Threshing efficiency
Out put capacity
Cost of operation

Cost economics

The cost of operation was calculated for the thresher in rotary mode of operation through bullocks and was compared with traditional practice using threshing bench. The following assumptions were taken for calculating the cost (Table 2)

RESULTS AND DISCUSSION

The sun flower thresher was operated in no-load condition with the rotary system. The results are presented in table 3. It was observed that the draft requirement was between 212 N initially and increased to 223 N after three hours of operation with a mean value of 219 N. which is 3.6 per cent of the bodyweight of the bullocks (bodyweight: 620 kg pair^{-1}). The speed of operation of the bullocks varied between 3.15 to 2.32 kmh^{-1} from 0.5 to 3 hours. The mean pulse rate, respiration rate and body temperature were 65 beats min^{-1}, 29 blows min^{-1} and 38.4 ^{O} C respectively. The average power output over three hours was 0.23 kW.

The data on evaluation of the sun flower thresher in rotary mode has been presented in table 4. The draft requirement varied 518 N in the beginning to 458 N at the end. The mean draft was 484 N which was 7.9 per cent of the bodyweight of the bullocks. The increase in pulse rate and respiration rate as usual decreased with duration and varied between 67 to 89 and 25 to 55 within three hours respectively. The corresponding mean values were 78 and 40 respectively. There was not much variation in the body temperature. Observations on half hourly RPM of the bullocks gradually deceased from 66 to 44 with duration so also the linear speed.

The mean linear speed of the bullocks was 2.15km h^{-1} and the corresponding thresher drum peripheral velocity was 4.84 ms^{-1}. The mean RPM of the threshing drum was observed to be 380. Threshing efficiency varied between 92.5 to 96.2 per cent with a mean of 93.65 per cent. 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 66.98 kg ha^{-1}. The power output was found to be 0.295 kW which indicated that the bullocks were underutilized as far as power utilization is concerned. The bullocks could sustain the duration of threshing without getting fatigue as the average fatigue score was only 11. The cost of sun flower threshing by the developed thresher in rotary mode was found to be Rs 69.65 q^{-1} while it was Rs 250 q^{-1} in traditional method of manual threshing by the Threshing Bench (Table 5). This was due to higher output of 66.98 kg ha^{-1} achieved by the feed-in type sunflower thresher operated bullocks in rotary mode as compared to 10kg ha^{-1} in conventional manual threshing bench method.

The following conclusions are made from the study:

i) The draft requirement of the thresher was very low in term of percentage of body weight *i.e* 6.9 per cent for thresher. So the bullocks could sustain the draft for three hours.
ii) The cost of operation for threshing using the developed feed-in type sunflower thresher in rotary mode was found economical as compared to conventional manual threshing bench method.

The use of sunflower thresher in rotary mode will increase the annual use of bullocks by the farmers; thereby the burden of maintenance cost bullocks on farmers (owning bullocks) will reduce making the bullock farming system more effective and sustainable.

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