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Development and compare performance evaluation of traditional, pedal operated and modified pedal operated portable paddy thresher for small farmers

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Abstract
Today there are various machines for performing various kinds of operations in farm as well as for doing every work, where considering our research we have found for study i.e." Rice Threshing, here we found various problems that has to be noted and can be worked on. So this problems can be framed as the machines that are used for rice threshing are required more man power for threshing i.e. if one labour standing with rice plant for threshing behind the thresher it's difficult to rotate rice plant continuously in standing position with rice plant. So, there need to develop new technique or machine that can be used solve the problem mentioned above. Currently, The Traditional, portable paddy thresher and Modified paddy thresher was tested for its performance in terms of threshing efficiency, grain damage and output capacity at different levels of factors namely concave clearance (15, 20 and 25 mm), cylinder peripheral and Comparing the maximum threshing efficiency, minimum grain damage and maximum output capacity in different combinations the minimum loss was achieved.

Keywords: Traditional threshing, pedal operated rice thresher and modified pedal operated rice thresher

Introduction
Rice (*Oryza sativa* L.) is the main crop in India grown in about 44.01 million ha area produces 105.30 million tonnes in 2011-2012 (Anonymous, 2015) [4]. India is one of the world's largest producers accounting for 20% of global rice production. The regions with rich bio-diversity and varying agro-climatic conditions have tremendous potential to increase the productivity of rice. Total 75% farmers are small and marginal farm holder (<2 ha) (Birthal *et al*., 2006) [8] are not capable of purchasing higher machinery like power thresher, instead of its, farmers used to hire the machinery but which still not meeting the needs of the farmer. The land-to-person ratio for some region (0.68 ha person-1) is much higher than the national average (0.32 ha person-1) (Anonymous, 2011) [3]. Although farmers continues to be a net importer of food grains as despite covering 8.8% of the country's total geographical area, it produces only 1.5% of the country's total food grain production (Patel *et al*., 2013) [15].
At present, it is estimated that farm power availability in the most region is 0.67 kW ha-1 which is much lower than the national average of 1.15 kW ha-1 (Kaul, 2001). The traditional rice threshing performed by hand; bunches of panicles are beaten against a hard element (e.g., bamboo table, a wooden bar or stone) or with a flail. The outputs are 10 to 30 kg of grain per man-hour according to the variety of rice. This method leads to the grain loss amount is around 1% to 4% (Paulsen *et al*., 2015) when threshing is performed excessively late; some unthreshed grains can also be lost over the threshing area. Traditional threshing methods trampling with humans and animals incur enormous losses (Belay *et al*., 2013) [7]. Increased rice production, the inefficiency of manual threshing, seasonal drudgeries of women worker and children, and subsequent losses require the implementation of improved threshing machines (Azouma *et al*., 2009) [5]. Farmers mostly prefer to carry machine like the thresher by a single man for which machine weight should be less than 35 kg (Singh *et al*., 2008) [21]. Existing thresher available from region (power as well as manual thresher) is not comfortable to fulfil the needs of farm workers. Due to non-availability of power thresher to every corner of area; threshing is still practiced by pedal operated paddy thresher (POPT). However, many studies revealed that the threshing machine was responsible for severe injuries due to inadequate design.

Many raditional methods of threshing require manpower input in the range of 80-120 man-h ha-1 whereas pedal paddy thresher requires about 35-40 man-h ha-1, which means considerable savings in time and cost (Agrawal, 2008) [2]. The existing paddy thresher encountered problems of wrapping of paddy stalks due to the clearance between the drum and concave, inadequate threshing due to fewer numbers of strips on the periphery of the thresher drum. Thus, the objective of the present study is to optimize structural machine parameters to enhance maximum threshing capacity using response surface methodology (RSM) and central composite rotatable design (CCRD) techniques.

Rice, as a cereal grain is the most widely and commonly consumed food by an enormous part of the world's population. Rice a crop ranked third in worlds most produced crops, behind sugarcane and maize according to FAOSTAT (2012) data.

Rice provides caloric nutritional needs and hence, grown in different environments where water is readily available for irrigation. Rice requires sufficient water to grow. Although its parent species are native to Asia and certain parts of Africa, centuries of trade and exportation have made it commonplace in many cultures worldwide (Wikipedia, 2016) [23]. The soil used in growing rice should have a good water holding capacity.

Table 1.1: Production of paddy in world

Sr. no.	Country	Production (million tone)
1	India	112.9
2	China	204.3
3	United state	107.33
4	Thailand	27.06
5	Brazil	11.21
6	Vietnam	6.7
7	Uruguay	3
8	Pakistan	42
9	Italy	1.3
10	Africa	14.6

The general name for machines that involve the process of removing grains from ear heads of crops is a thresher. Threshers were first invented by Scottish mechanical engineer, Andrew Meikle for agricultural use (Wikipedia, 2015).

In 1784, the thresher was invented to separate grains from stalks and husks. Mechanical threshers could be manually operated or motorized. The manual rice threshers, which included the foot operated rice thresher were evaluated to determine threshing speeds, losses and drudgery in the process of threshing. The foot operated rice threshers were considered since the mechanically operated rice threshers are cost demanding for local farmers. The inefficiency of manual threshing and winnowing, seasonal drudgeries of the women and the children in India worsens its losses, damaged and broken grains sensitive to the damage of storage and commercial low value. The policies which promote the local production as well increase the workload of the producers. So manual threshing and winnowing being already arduous require more labour. In considering the evaluation of the foot operated threshers suitable for small-scale rice farms, a number of key factors would be considered. These may include comparing their threshing rates, their threshing losses, their output quality and their ease of use as well. The foot operated rice threshing machines were tested with the aim of assessing the threshing performance and gathering feedback from farmers to evaluate the efficiencies of the foot operated rice threshers to determine which will be suitable for local rice farmers.

Maharashtra is located in the western part of India along the Arabian Sea. It lies between 15° 44' to 22° 6' N and 72° 36' to 80° 54' E. The total area of Maharashtra State is 307,000 square kilometres, which is 9.36% of the country. Considering the area and population, Maharashtra state is the third largest state in India. The population of the state is 80 million which is 9.47 % of the country's total population. In Maharashtra rice is the second important crop of the people, which is grown over an area of 14.99 lakh hectares with an annual rough rice production of 32.37 lakh tones. The average productivity of the state is 2.01 t/ha. Maharashtra ranks 13th place in rice production in country. The average productivity of the Maharashtra state is low as compared to other rice growing states *viz*. Punjab, Tamil Nadu, Haryana, Andhra Pradesh, etc.

Table 1.2: The region wise area, production and productivity in the State are as below

Sr. No.	Region	Area (lakh ha)	Rice / Rough rice production (lakh tones)	Rice /Rough rice productivity (t/ha)
1	Konkan	4.136	10.42/15.10	2.56/3.65
2	Western Maharashtra (Rice growing districts)	3.298	6.08/8.82	1.85/2.67
3	Marathwada (Non traditional rice growing area)	0.242	0.10/0.14	0.42/0.59
4	Vidarbha	7.319	5.73/8.31	0.78/1.14
5	Total	14.995	22.34/32.37	1.39/2.01

Ref: Maharashtra State Statistics Dept. Pune (2008-09).

The area (7.32 lakh ha) of rice crop is more in Vidarbha region. The highest productivity was observed in Konkan region i.e. 2.56 t/ha (3.65 t/ha for rough rice). Marathwada region is the non-traditional rice growing area. Due to the erratic and less rainfall in Marathwada region, the average productivity of rice crop is lowest i.e. 0.41 t/ha (0.59t/ha for rough rice).

Methods and Material

- **Study site description**

This study was conducted in Saralgaon, District Thane of Kokan region, Maharashtra. Demonstration sites were selected purposively in the project area with Two (2) farmers research extension groups (FREGs) were established as a means for evaluation and promotion of the technologies though lateral extension system and feed backs collection. The pedal and modified rice threshers were demonstrated at the first and second years of the project respectively.

- **Traditional rice threshing**

Threshing rice in Saralgaon is done traditionally. The traditional threshing methods are beating by stick and animal trampling. Beating involves pounding shelves of rice crop on hard surface or beating the ear of the crop with stick. Animal

trampling is treading a layer of 15 to 20 cm thick harvested crop by a team of animals followed by manual refining, depending upon capacity, lot size and situation. Threshing by animal treading is practiced on large scale in the country but it is also time consuming and involves drudgery. Animal trampling (here after referred as traditional) on average takes two human labour and 5 oxen for 10 hrs to produce 1 tone output of fairly dried rice. However, include huge loss due to spreading, fracture and mix up with soil impurities. Absence of sufficient livestock for trampling forces prolonging threshing period thereby increasing loss due to shattering, pests and rotting of grains. If threshing animals are not available, the farmers will thresh by stick beating little by little thereby exaggerating the loss.

Fig. 2.1: Traditional Thresher

- **Pedal operated thresher**

The pedal thresher consists of an open rotating drum with wire loops. The drum strips the grains from the panicles when fed by hand. The Pedal Rice thresher was simple to operate with leg muscle, doesn't consume fuel and it is used for threshing paddy rice easily. It can also be operated by women and can be used in hilly or terraced areas because of its portability.

Specification

Power: human labour (Gear mechanism).
Labour requirement: 2 persons.
Weight:
Dimension (L*W*H):(66×56×65) cm
Capacity:
Threshing drum height: 53.5 cm
Threshing drum radius: 16.3 cm
Peg diameter: 2.8cm
Peg length: 5cm
Pedal (L×T×W): (58.4×2.4×5) cm
Construction Materials: Steel Metal

Before these processes of threshing were carried out, the initial pressure readings of the farmer were taken and an amount of 1 kg of rice was threshed for 4 trials using the pedal operated rice threshers each, with in which initial and final pressure readings were taken as well as the speeds of the threshing drum and using a stop watch, which aided in determining the threshing rate for the processes.

Fig 2.2: Pedal operated rice thresher

- **Modified pedal operated thresher**

The Modified Pedal Operated Thresher is same as the Pedal operated thresher. The modification is done using the sieve added to the thresher, to obtain clean paddy grains without straw. The measurement of the steel sieve length 102cm, width 60.5cm is frame with metal.

Fig 2.3: Modified pedal operated paddy thresher

Theoretical Consideration

Data collection and analysis

- **Data collection**

Samples were taken on the two threshers to measure their threshing efficiency and capacity. Opinions, views and response of the participants about the technology as compared with the traditional practice were collected.

Threshing by the pedal type thresher and traditional methods were conducted using rice variety. The threshing was done for 10 minutes on each practice. Sample was collected from 5 trainees for pedal type and from 3 trainees for traditional method.

- **Financial analysis**

For financial analysis a price tag is assumed, including 10% labour cost and 10% profits for both the traditional and the pedal threshers. A service life of 10 years with constant depreciation, 5000 working hours and maintenance cost of 7% is considered for the threshers. Thus, annually the thresher can be used for 500hrs and annual investment cost. A monthly interest rate is taken for the opportunity cost of cash of the farmers as most likely they will save it in the formal Banks, considered as the next best opportunity. Although equal price is set for both rice threshed by traditional and pedal threshers is expected to fetch better price due to better quality.

- **Determination of loss percentage**

The following relationship was used to calculate the percentage losses of the traditional thresher, pedal operated paddy thresher and modified pedal operated paddy thresher with sieve.

$$\text{Scattering losses percentage} = \frac{\text{Scattered grains(kg)} \times 100}{\text{Total seeds(kg)}}$$

- **Determination of threshing capacity**

The following relationship was used to calculate the capacity of the traditional thresher, pedal operated paddy thresher and modified pedal operated paddy thresher with sieve.

$$\text{Threshing capacity} = \frac{\text{Total grains input(kg)} \times 60}{\text{Total time in minutes}}$$

- **Determination of Threshing efficiency**

The following relationship is used to calculate the efficiencies of the traditional thresher, pedal operated paddy thresher and modified pedal operated paddy thresher with sieve.

$$\text{Threshing efficiency} = \frac{\text{Threshed Seed (kg)} \times 100}{\text{Total seeds}}$$

- **Determination of moisture content**

Moisture content of grain and straw was determined by taking sample during each test. Total 100 gm of grains were taken and 10 gm sample of straw was collected and filled in the moisture boxes. Then boxes were kept in the hot oven for drying at 105^0C for 24 hour. After drying, the dried weight was noted. The moisture content (wb) was found out by formula,

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{Drying weight}}{\text{Initial weight}} \times 100$$

- **Determination of grain ratio**

The weight of sample of paddy crop was measured and noted. Then sample was threshed manually and the total weight of the grain was measured. Weight of the straw was measured. The grain ratio was calculated by dividing weight of grains by weight of the straw.

$$\text{Grain ratio} = \frac{\text{Weight of grian in sample}}{\text{Total weight of sample}}$$

A = Total grain input per unit time by weight, kg/h

- **Determination of cleaning efficiency**

$$\text{Cleaning efficiency} = \frac{\text{I}}{\text{J}} \times 100$$

Where,

I = Weight of whole grain per unit time at main grain outlet, kg/h

J = Weight of whole material per unit time at the main outlet, kg/h

9. Cost economics of thresher

The operating cost of the newly developed thresher, the fixed cost, variable cost and operating cost were determined by formulas given below. Here life of thresher and use of machine are considered as 10 years and 250 h/year respectively (Jadhav R. T. 2009).

Results and Discussion

We compare various parameter of the traditional method, pedal operated paddy thresher and modified pedal operated paddy thresher**.** We find some parameter of the thresher are as follows

1. Scatter losses
2. Grain ratio
3. Threshing capacity
4. Threshing efficiency
5. Cleaning efficiency

- **Threshing capacity**

The threshing capacity of the thresher depends on Paddy rice holding capacity of the operator at once with hand, feeding rate of the operator, threshing unit /drum rpm and the variety of the rice and other factors. In addition, driving mechanism may influence the threshing capacity. Gear drive is more efficient than chain drive. The efficiency of gear drive was 99% while chain drive was 95%. This difference in driving mechanism efficiency comes up to different rpm on the threshing drum. This enters influence the capacity of their threshing per hour. The modified pedal operated has slightly higher output than the pedal operated thresher.

We take some paddy sample in gram then we dry to it. Then we take test on traditional method, pedal operated paddy thresher, modified pedal operated paddy thresher. Then we find threshing capacity by the formula.

- **Threshing efficiency**

Spreading the rice panicles over the drum was essential for threshing efficiency. The person should size a manageable size for accessing the beaters or else should turn the sides of the panicles and rotate to thresh. There is no paddy rice left over with the rice straw in the pedal as well as the modified one. The threshing efficiency of the machine was 100% Overall analysis of the comparative evaluation of the technologies resulted in significant difference on the average output between the traditional method, the pedal operated and modified pedal operated paddy thresher demonstrated. However, significant difference was observed on traditional thresher output compared to pedal operated and modified peadal oprated thresher. Further test showed the absence of significant threshing capacity difference between the pedal and the modified thresher. However, the capacity was significantly higher for both technologies compared to the traditional system at 1% level of significance.

We take some paddy sample in gram then we dry to it. Then we take test on traditional method, pedal operated paddy thresher, modified pedal operated paddy thresher. Then we find threshing efficiency by the formula.

We took four tests of paddy (500 gram, 1000 gram, 1500 gram, 2000 gram.) for each method. Some data is obtained are as follows. Traditional, Pedal Operated and Modified Pedal Operated threshing performance shown in table.

Table 4.1: Traditional thresher

Time (min)	Weight (g)	Scattered Loss (%)	Threshing Capacity (g/min)	Threshing Efficiency (%)	Grain Ratio (%)	Cleaning Efficiency (%)
1.3	500	26.63	9876.92	97	0.42	43.8
3	1000	45.6	5000	95	0.25	25
4.3	1500	36.01	6934.88	90	0.33	33.13

Table 4.2: Pedal operated paddy thresher

Time (min)	Weight (g)	Scattered Loss (%)	Threshing Capacity (g/min)	Threshing Efficiency (%)	Grain Ratio (%)	Cleaning Efficiency (%)
1	500	16.14	13380	98	0.446	44.6
2	1000	20.1	11790	97	0.393	39.3
3	1500	12.81	12640	95	0.35	43.13
4	2000	17.68	12645	97	0.4215	42.15

Table 4.3: Modified pedal operated thresher

Time (min)	Weight (g)	Scattered Loss (%)	Threshing Capacity (g/min)	Threshing Efficiency (%)	Grain Ratio (%)	Cleaning Efficiency (%)
1	500	8.05	14160	99	0.472	47.3
2	1000	10.6	13290	98	0.443	44.3
3	1500	8.91	13680	97	0.45	45.6
4	2000	9.19	14190	96	0.473	47.3

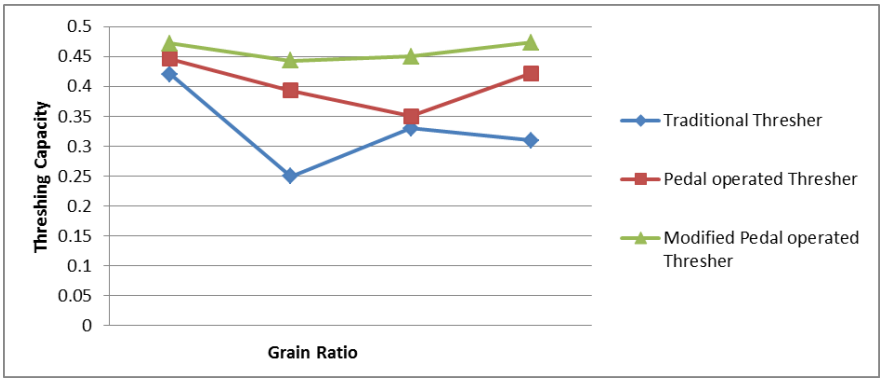

Fig. 4.1: Threshing efficiency vs grain ratio

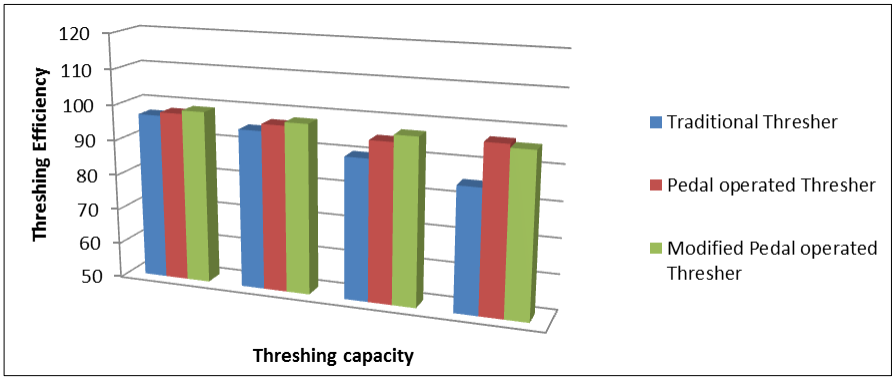

Fig 4.2: Threshing efficiency vs threshing capaity

Conclusion

The design and fabrication of a Modified pedal operated paddy threshing machine has been successfully carried out by this work. The machine is capable of threshing, separation of stalk from grains and reduction in number of broken grains, thereby, giving a better method of threshing than the traditional methods. In addition to it the safety of the operator has also been enhanced. All the materials used were locally sourced.

1. The pedal operated paddy thresher had a capacity of 40.68kg/hr.
2. The heart rate per kg in using the pedal operated paddy thresher was recorded as 32 beats/kg,
3. The pedal operated paddy thresher recorded an average speed of 158.3rpm in operation. The pedal operated paddy thresher recorded 29.6% losses during operation.
4. In modified pedal operated thresher with sieve, scattering loss is less than the pedal operated thresher and traditional method.
5. The time required for threshing in pedal operated thresher is less than traditional method.
6. Threshing efficiency of modified pedal operated thresher is greater than other two method.
7. Cleaning efficiency is greater than the pedal operated paddy thresher and traditional method.

So, the modified pedal operated paddy thresher is more effectively than other two method. The machine price is less so the farmer can be buy for the harvesting of rice for personal farm.

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