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Performance evaluation of different methods of Ragi threshing in Odisha (India)

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Abstract
Generally, finger millet (ragi) crop is harvested manually and transported to threshing yard, where it is threshed either by beating the crop manually with sticks or by foot trampling method which was very labor oriented, tedious, uneconomical, and low food value product due to the presence of foreign particle but also leading to considerable amount of loss of grain during the threshing process. This comparative study of different ragi threshing shows that how these losses minimized by switching towards mechanical threshing but still the results could be improved by adopting some new or modified mechanical thresher. The output, threshing efficiency and unthreshed grain are 43.75 kg/h, 78.12 and 5.97 per cent in case of developed thresher cum pearler whereas 9.12 kg/h, 70.81 and 1.93 per cent in case of pedal operated thresher, respectively. Again, the output and threshing efficiency of hand beating method are 6.4 kg/h and 95.69 per cent where 6.9 kg/h and 97.72 per cent in case of foot trampling method, respectively. The cost of operation of motor operated thresher is approximately half as compared to conventional method *i.e.* 5.24 Rs/kg, 4.2 Rs/kg, 2.73 Rs/kg, 1.53 Rs/kg, and 1.73 Rs/kg in case of hand beating, foot trampling, pedal operated, existing thresher and developed thresher cum pearler, respectively.

Keywords: Ragi, thresher, output, threshing efficiency, cost of operation

Introduction
Millets are very important food of tribal people and believed to be first domesticated cereal crop which is mostly grown in tribal and hilly areas of India and many Asian and African counties (Gbabo *et al.*, 2013) [1]. It has been reported that the air-dried grain of millet contains approximately 12.4% water, 11.6% protein, 5% fat, 67.1% carbohydrate, 1.2% fiber and 2.7% ash (Onwueeme and Sinha, 1991) [2]. The finger millet's dietary fiber and polyphenols have been recognized to offer several health benefits such as anti-diabetic, protection from diet related chronic diseases, antioxidant, and antimicrobial effects to its regular consumers. Moreover, very nutritious and important crop for balanced diet, rich in vitamins, protein, carbohydrate, minerals, fibers, iron, amino acid, phosphorus, magnesium, potassium, and also good source of energy. (Anonymous, 2001) [3].
In Odisha, ragi (Finger millet) is grown in 55,000 ha area with annual production of 30,910 MT and productivity of 5.62 q/ha. Finger millet is harvested either manually by using sickle if it is intercropped with legumes or by reaper windrower if it is grown as mono crop. It is estimated that harvesting and threshing of crops consume about one third of the total energy requirement of the production system (Sreenatha, 2010) [4]. Traditionally, in tribal and hilly areas, threshing of millet crop is done either beating by sticks or by treading out the crop panicle under the feet of oxen. This method often results in some losses due to the grain being broken or buried in the earth which leads to low quality product due to the presence of impurities like stones, dust, and chaff etc. These threshing operations are mostly time consuming, energy intensive (19.9 kJ/min), labour intensive, drudgery prone and uneconomical. The mechanized threshing of millets can reduce the drudgery of farmers/labours, improve the quality of product (Singh *et al.*, 2015) [5].
Considering the need of preparation of threshing yard, transportation of harvested crop to the threshing yard, peak threshing period availability of tractor and simplicity of millet thresher, high output, low operating cost, higher threshing performance it is better to adopt power operated thresher for ragi threshing (Hanumantharaju *et al.*, 2017) [6]. Hence, in this study, different ragi threshing methods have been compared in terms of output, efficiency and cost of operation with the newly developed ragi thresher cum pearler to identify the most efficient and economical method of ragi threshing in Odisha.

Material and Methods

Various data recorded during the process of evaluation are described in the succeeding sections.

Moisture content

The moisture content of the grain was determined by oven drying method by placing 15g of grain seed samples in air ventilated oven at105°C for 24 hours and then cooling the sample before weighing (USDA, 1970) [7] and expressed in per cent wet weight basis:

Grain ear-head ratio

The ratio of grain to straw was calculated by dividing the known quantity of crop containing grains by the grains threshed out of it and expressed in the form of grain straw ratio (Mohsenin, 1970) [8].

Output capacity

The output capacity was estimated by weighing the total grain (whole and damaged) received per hour at main grain output of the thresher as presented in Eq. 1 (Mohsenin, 1970) [8].

$$Output\ capacity(kg/h) = \frac{wieght\ of\ grain\ threshed(kg)}{time\ taken(h)} \quad (1)$$

Unthreshed grain:

The per cent of' unthreshed grain was estimated by separating by the whole grains attached to the threshed ear heads of known quantity manually using the following formula as shown in Eq. 2 (Mohsenin, 1970) [8]:

$$Percentage\ of\ unthreshed\ grain(\%) = \frac{H}{A} \times 100 \quad (2)$$

Where,
H = Weight of unthreshed grain per unit time at all outlets
A = Total grain input per unit time by weight

Threshing efficiency

The threshing efficiency was estimated by using the formula and expressed in percentage, as shown in Eq. 3 (Mohsenin, 1970) [8]:

$$Threshing\ efficiency(\%) = \frac{(A-H)}{A} \times 100 \quad (3)$$

where,
H = Weight of un-threshed grain per unit time at all outlets
A = Total grain input per unit time by weight

Cleaning efficiency

The cleaning efficiency was calculated by using formula and expressed in percentage as shown in Eq. 4 (Mohsenin, 1970) [8].

$$cleaning\ efficiency(\%) = \frac{I}{J} \times 100 \quad (4)$$

Where,
I = Weight of whole grain per unit time at the main grain outlet
J = Weight of whole material per unit time at the main outlet

In the irrigated crop the ear heads and straw are harvested separately engaging manual labour with sickle. In the rain fed crop the whole crop is harvested about 3 to 4 inches above the ground level engaging manual labour with sickle. The harvested crop is then transported to threshing yard, where threshing is done by local practices means by manual hand beating & foot trampling and beaten against hard elements (e.g., a wooden bar log, bamboo table or stone). In many areas, the crop is threshed by being trodden underfoot by humans or animals.

Evaluation of manual hand beating method

A man having a good physique with previous experience in threshing was selected as a power source. A known quantity of ragi ear heads having 12 to 14 per cent moisture content (wb) was used as a test material. The material spread over the threshing yard about a thickness or height of 7-10 cm. Then go for the method of beating and trampling by manually. The time taken to thresh the known quantity of material by manual hand beating with long stick and trampling by foot, Output capacity, broken grains, un-threshed grains, threshing efficiency and cleaning efficiency were recorded.

Evaluation of pedal operated ragi thresher

The evaluation of pedal operated ragi thresher was conducted in CAET, OUAT campus and operated by a man means 0.1 hp where the output is around 6-8 kg/h. Only the ear-heads are feed to the chamber where it gets threshed and separated from the ear-head and going out from the chamber through the concave and clean from the foreign element by the help of a blast of air coming from the blower.

Evaluation of existing ragi thresher (VPKAS, Almora, Uttarakhand)

This thresher was developed at Almora, Uttarakhand in 2008. It is operated by a 1 HP motor with the canvas strips as the threshing element. Here only ear heads are used as the feeding material. Both the process means threshing and pearling is done individually means first we have to feed the ear heads for threshing and again the output feeding for pearling. It is evaluated and operated in CAET campus. In this thresher the cylinder outlet is present just below the cylinder which allows the material to the sieve. The sieve which separates the straws, chaffs from the grain and allow the material to main outlet. In the passage from sieve to outlet the grains are further cleaned by the blower which separates the lighter particle present in it with the help of blast of air.

Performance of developed feed in type ragi thresher-cum-pearler with blower

The performance of the prototype thresher-cum-pearler with blower arrangement was evaluated at three different varieties of ragi ear head with different moisture content of ear head. Observations like output, threshing efficiency, cleaning efficiency, un-threshed and broken grain per centage were done and presented in Table 5.17.

Results and Discussion

The above evaluations were done in CAET CAMPUS with "*Bhairabi"* variety and compare the performance results with different methods of ragi threshing practices. The crop parameters are listed below in (Table 1):

Table 1: Crop parameters

Name of crop	Ragi
Variety	*Bhairabi*
Grain/crop ratio	4
Diameter of ear- head fed, cm	4-6
Height of ragi ear-head, cm	7-9
Moisture content of ear head, %	11.00
Moisture content of seed, %	12.00

Performance evaluation of conventional method of ragi threshing

The moisture content of the test crop was 12.24 to 12.59 per cent (wb) of seeds and 11.59 to 11.92 per cent (wb) of ear heads. The output observed as 6.4 – 6.9 kg/h, threshing efficiency as 95.69 to 97.72 per cent and un-threshed grain as 2.92 – 2.05 per cent (Table 2).

Performance evaluation of pedal operated ragi thresher

When we go for the combination of moisture content of the test crop was 11.21 per cent (wb) of ear head and 12.09 per cent (wb) of seeds then the output observed as 9.12 kg/h, threshing efficiency observed as 70.81 per cent, the un-threshed grain as 1.93 per cent and cleaning efficiency as 88.23 per cent are also presented in the Table 2.

Performance evaluation existing ragi thresher

The threshing operation was done within the moisture range of ear head at 11.59 per cent whereas grains moisture content was 12.24 per cent. The avg. output of is 35.4 kg/h whereas threshing efficiency is 70.5 per cent. Similarly, the cleaning efficiency is 83.1 per cent. The un-threshed and broken grain were 1.82 and 2.9 per cent, respectively (Table 2).

Performance evaluation of developed ragi thresher cum pearler with blower

After sun drying, for threshing operation the crop was taken at moisture content of ear head at 11.87 per cent whereas grain moisture content was 12.74. The average output of "*Bhairabi"* varieties is 43.75 kg/h whereas threshing efficiency is 78.12 per cent. Similarly, the cleaning efficiency is 81.05 per cent. The un-threshed and broken grain varies with in the range of 5.97 and 4.83 per cent, respectively (Table 2).

Table 2: Performance report of ragi threshing

Items		Manual hand beating method	Manual foot trampling method	Pedal operated thresher	Existing ragi thresher	Ragi thresher-cum-pearler with blower
Moisture content (%)	Ear head	11.92	11.59	11.21	11.59	11.87
	Grains	12.59	12.24	12.09	12.24	12.74
Output (kg/h)		6.4	6.9	9.12	35.4	43.75
Threshing efficiency (%)		95.69	97.72	70.81	70.5	78.12
Un-threshed grain (%)		2.92	2.05	1.93	1.82	5.97
Broken (%)		3.59	-	-	2.9	4.83
Cost of operation (Rs. /Kg.)		5.24	4.2	2.73	1.53	1.75

Compression of output capacity with different methods of threshing of ragi ear-head: Through the manual or conventional methods of threshing, we got the output around 6.4 kg/h and 6.9 kg/h (Fig. 1a) output in case of in case of hand beating method and foot trampling method respectively. Similarly, the evaluation was done with pedal operated thresher and existing ragi thresher where the threshing and pearling done in double pass but in case of developed ragi thresher-cum-pearler with blower threshing and pearling occurred in single pass while the outputs were 9.12 kg/h, 35.4 Kg/h and 43.75 kg/h (Fig. 1a & Table 2). The output we got with the motor operated threshers was around 5-6 times of the outputs of conventional hand beating and foot trampling methods.

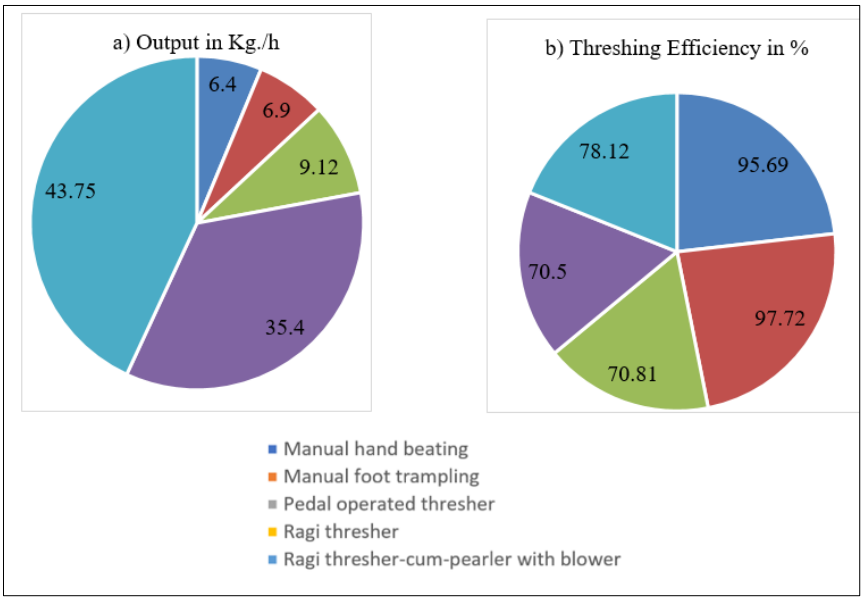

Fig 1: a) Compression of output capacity and b) threshing efficiency with different methods of threshing

Compression of threshing efficiency with different methods of threshing of ragi ear-head

The threshing efficiency higher in case of manual or conventional methods whereas in case of pedal operated and motor operated was a little bit lower. We got the threshing efficiency around 95.69 – 97.72 per cent in case of both the manual or conventional methods whereas 70.81, 71.5 and 78.12 per cent in case of pedal operated thresher, existing ragi thresher and developed ragi thresher-cum-pearler with blower respectively mentioned in Table 2 also shown in Fig. 1b.

Compression of unthreshed grain percentage with different method of threshing of ragi ear-head

Through the manual or conventional methods of threshing, we got percentage of un-threshed grain around 2.92 and 2.05 (Table 2) in case of in case of hand beating method and foot trampling method respectively. Similarly, the evaluation was done with pedal operated thresher, existing ragi thresher and developed ragi thresher-cum-pearler with blower where the unthreshed grain percentage is lower and a little bit higher in case of ragi thresher cum pearler with blower as compared to conventional method as depicted in Fig. 2a.

Comparison of cost of operation with different methods of threshing

For getting one kg of grain through conventional method is around Rs. 4-5/ kg whereas 2.73, 1.53 and 1.75 Rs. /Kg. in case of pedal operated thresher, Existing ragi thresher and developed ragi thresher-cum-pearler with blower respectively as shown in Fig. 2b. The cost of operation of manual methods is approximately two times of the power operated and pedal operated thresher which is very economical to farmer to adopt.

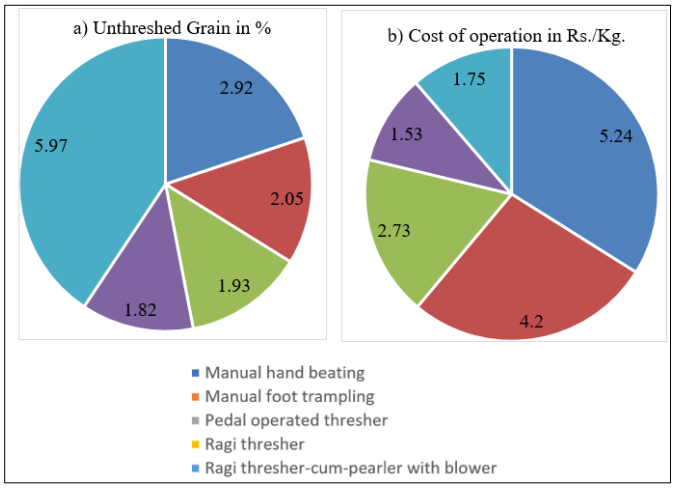

Fig 2: a) Compression of unthreshed grain and b) cost of operation with different methods of threshing

Conclusion

From this study, it is concluded that the power operated thresher is better to adopt for farmers because it can minimize the threshing time as well as reduce the drudgery involving in the manual threshing. Going towards mechanization in millets is better to adopt motorized threshers than manual methods where we can get a clean product which is free from trashed and other foreign materials which gives us a higher food value. We can get a larger output and less cost of operation with less time of operation. But still, we need some modification of thresher to reduce the broken grain and unthreshed grain per centage. The output, threshing efficiency and unthreshed grain are 43.75 kg/h, 78.12 and 5.97 per cent in case of developed thresher cum pearler with blower whereas 9.12 kg/h, 70.81 and 1.93 per cent in case of pedal operated thresher, respectively. Again, the output and threshing efficiency of hand beating method are 6.4 kg/h and 95.69 per cent where 6.9 kg/h and 97.72 per cent in case of foot trampling method, respectively. The cost of operation of motor operated thresher is approximately half as compared to conventional method *i.e.* 5.24 Rs/kg, 4.2 Rs/kg, 2.73 Rs/kg, 1.53 Rs/kg, and 1.75 Rs/kg in case of hand beating, foot trampling, pedal operated, existing thresher and developed thresher cum pearler with blower, respectively.

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