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Portable rice thresher model compatible for rural small scale farmers

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ABSTRACT

Although rice threshing is a strenuous and time consuming process machine threshing is not implemented by farmers in Nagaland and many northeastern states of India. In 2018, a study was performed to develop a portable rice thresher to suit rural farming condition. The thresher was constructed in separate parts and assembled together. Each separate component can be dismantled for easy transportation. The rice thresher can be operated through foot pedal and handle. The straw feeder height of the thresher was 94 cm and total weight of thresher was 35 kg. The efficiency of threshing was 97% with threshing cylinder speed of 270 rpm. The thresher was introduced to few farmers in 2018 harvest season and utilized successfully without any mechanical defect. Qualitative assessment by farmers reported that although there was no difference in threshing time, machine threshing caused less physical stress compared to traditional method of threshing.

1. Introduction

Rice is the staple and most commonly grown crops among the farmers in Nagaland (Directorate of Economics and Statistics 2013). Generally, rice cultivation is performed by manual labour from the time of seeding to harvest. Rice threshing is a strenuous labour intensive post-harvest activity. It demands great physical strength and energy investment. Although, rice threshing machines are used in other parts of India, farmers in Nagaland especially the rural famers rely on traditional foot threshing or beating with wooden sticks (Singh *et al.*, 2011). This is partly because of non-exposure of farmers to mechanization, available compatible technology and likely because of economic condition. Thus, threshing is still performed through traditional methods using manual labour. The use of compatible technology at various stages of cultivation practice reduces total farming cost (Singh and Devi 2016). Studies on ergonomics of threshing reported that mechanization of threshing reduces physical stress, and investment of energy compared to traditional threshing methods (Kwatra *et al.,* 2010; Agarwal *et al.,* 2012; Sam 2012; Khadatkar *et al.,* 2018).

Additionally, designing of machine suitable for the stature of user is an important aspect for greater benefit of the users and reduce occupational health hazards (Patel *et al.,* 2017; Kumar *et al.,* 2002; Khayer *et al.,* 2017). Several designs of rice thresher both manual pedal operated and motorized threshers are in use in different rice producing areas (Azouma *et al.,* 2009; Shahi *et al.,* 2016). But suitability of design may differ depending on the farm location, farm infrastructure, transportation and cost of the machine. Often, there is no electric connectivity in farms and the cost of fuel and motor operated design can be unmanageable for farmers (Baruah and Bora 2008). Moreover, the fields are usually located far away from the core of the villages and most of the fields do not have proper road connectivity, therefore transport of heavy machine creates inconvenience that reduce usability of the developed tools. Therefore, mechanization using compatible technology such as manually operable tools with multiple detachable parts that can be easily assembled for ease of transport is more suitable for such places. The objectives of this study were to design a portable rice thresher with an aim to reduce physical stress, is cost effective, convenient for transportation, and easily manageable for rural farmers in Nagaland and farms in rural places.

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Thresher components

This study was conducted in 2018 in Nagaland. The rice thresher was constructed using locally available materials so that this model can be replicated conveniently by the users in Nagaland. Additionally, the design and specification was made simple to allow easy replication using similar available materials in other places. The material needed include: a pair of bearings (UCP204, MPZ GOLD), fabricated iron bars (angle, square and flat bars), 6 mm rod for hooks and top cover, meshed cloth for top cover, gear wheels (Sagar Udyog, Sagar House, Kohima), 2.4 cm (outer diameter) metal hollow pipe for main shaft, aluminium sheets for receiver body, nuts and bolts. The machine was constructed in separate parts and assembled. Each part could be dismantled by the users when needed. The purpose of construction of machine in separate components was to accommodate ease of transport to farms. The individual parts consists of the threshing cylinder with looped hooks attached to main shaft and bearing, two separate main frames, receiver body, pedal gear wheels, straw feeder console, top cover, foot pedal, handle, and main frame connecting bars (Figure 1). All parts of the machine were built using fabricated metal, except for the receiver body which was made of aluminium sheet to reduce the weight. The height of the machine was determined following recommendation by Dewangan *et al.* (2010) to suit the comfort of user in northeast India with approximate stature range of 152- to 173- cm.

Thresher construction

The left and right side main frames of the thresher were constructed using angle bar. On the right main frame the foot pedal gear wheel was connected in a detachable housing. The foot pedal was constructed separately using flat and square bars. The threshing cylinder was built using lighter flat bars. Eight pairs of flat bars were lined at regular spacing to attach the cylinder hooks. The looped hooks, 8 cm height were made using metal rods and welded obliquely into paired cylinder bar with equal spacing of 5 cm. The hooks were placed alternately with 2.5 cm spacing corresponding to either adjacent paired bar. The center of cylinder was welded into the main shaft. The cylinder gear wheel and a bearing were attached at the right end of the main shaft and a bearing and handle base made of square bar was welded onto the left end of the main shaft. Separate receiver body was constructed using aluminium sheets with flat bar frame on the top end. The receiver body was gradually curved toward the lower end to shape into outlet for threshed rice. The two main frames were connected at the top using the extended flat bar attached to the receiver body and square bar connected to the foot pedal along with additional bar in the middle of the lower end and in center using nuts and bolts with provision to dismantle. A detachable straw feeder console, about 20 cm height was attached on the back side of the main frame. The top was built separately using 6 mm rods and covered with meshed cloth.

Performance test

The speed of threshing with and without load was determined by recording the rpm of the cylinder. The effectiveness of cylinder hook and efficiency of the machine was tested using freshly harvested rice panicles at 23% moisture content. The moisture content of the rice was determined by oven drying the rice to constant mass after threshing. The efficiency of threshing was measured as the ratio of rice grains detached from the straw to the rice grains remained attached to the straw

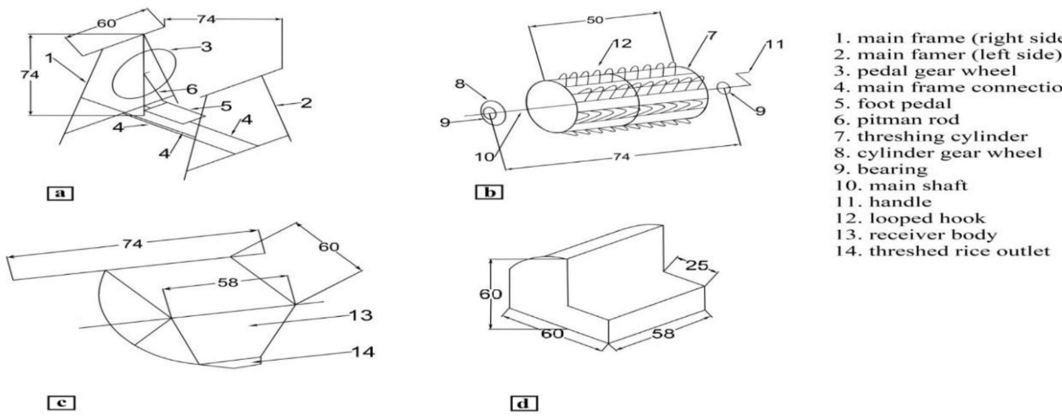

Figure 1. Depiction of individual components of the rice thresher indicating various specification dimensions in cm. (a) Main frame with foot pedal, pedal gear wheel, and main frame connection bars assembled, (b) threshing cylinder with permanently attached looped hooks, cylinder gear wheel, and bearings to the main shaft, (c) detached receiver body showing threshed rice outlet and (d) top cover of the thresher.

after threshing with machine (Amponsah *et al.,* 2017). A qualitative assessment of the user compatibility of the machine was tested by farmers during 2018 harvest season.

2. Results and Discussion

The finished product of thresher is shown in Figure 2 and detailed specification of rice thresher is given in Table 1. The height of the thresher from ground level up to straw feeder console was 94 cm. The thresher cylinder was about 10 kg which was the heaviest individual part and the total weight of the thresher was 35 kg. The thresher was tested using freshly harvested rice panicles. The thresher cylinder speed operated using foot pedal without feed was about 450 rpm and the working speed with load was about 270 rpm. The hook placement was found to be accurate as there was no strapping of the straw onto the cylinder during feeding. The efficacy as indicated by amount of grain removed from the rice panicle was found to be 97% as compared to 3% un-threshed grain remained on the panicles after threshing. The machine was used by few families of farmers during 2018 harvest season and their qualitative assessment was obtained. The farmers were able to use the machine without any mechanical defect during threshing. They found it more convenient to do threshing using the hand operation rather than foot pedal operation. They were convinced that threshing with machine was more relaxing and physically less stressful than traditional method of threshing. Farmers' qualitative evaluation reported that the ratio of threshed rice to time spend was same for both traditional and machine threshing. A constructive comment was to reduce the thresher height for convenience of the shorter stature users. Although, height of the feeder was suggested to be reduced for some users, previous research reported the optimum recommended feeder height for farmers in northeast region was estimated to be 96.9 cm (Dewangan *et al.,* 2010). An advantage of this thresher is having an alternative handle operation option that facilitates to use elevate platform for feeding according to user comfort if needed. The working cylinder rpm of this thresher is close to 300 rpm which was suggested to be the ideal speed to prevent un-threshed grain loss with increase in cylinder speed (Bawatharani *et al.,* 2012). A slight increase in length of rice stalk during harvest is recommended because rice panicles are hand feed onto the machine for threshing. Generally, rice is harvested in short stalk close to panicle for traditional threshing. But longer stalk is needed to hold while feeding on the thresher cylinder to avoid injury. Additionally, uniform bulking of the stalk or collecting in small bundle can accommodate faster processing. This rice thresher is designed especially to serve rural farm where lack of electrification and fuel cost can be a barrier for use of high powered machine. Having the option to dismantle into separate parts and easy process of assembling has added advantage for storage and transportation. This also allows convenient sharing of a machine among multiple farmers. Mechanization using compatible technology is becoming increasingly important in farming sector. With increasing demand for food and higher standard of living, farming without implementation of mechanized tools will reduce the efficiency of food production.

Table 1. Specification of rice thresher model constructed in Nagaland for small scale rice cultivators in rural areas.

Parameter	Specification
Main frame (l x b x h) [cm]	74 x 60 x 74
Receiver body (l x b) [cm]	58 x 60
Top cover size (l x b) [cm]	58 x60
Feeding console height [cm]	20
Threshing Cylinder radius [cm]	12
Threshing Cylinder length [cm]	50
Hook height [cm]	8
Hook placement (per bar) [cm]	5
Pedal height (from ground) [cm]	10
Thresher weight [kg]	35
Cylinder speed without load [rpm]	450
Cylinder speed with load [rpm]	270
Operation type	Foot pedal or handle
Feeding type	Hand feeding

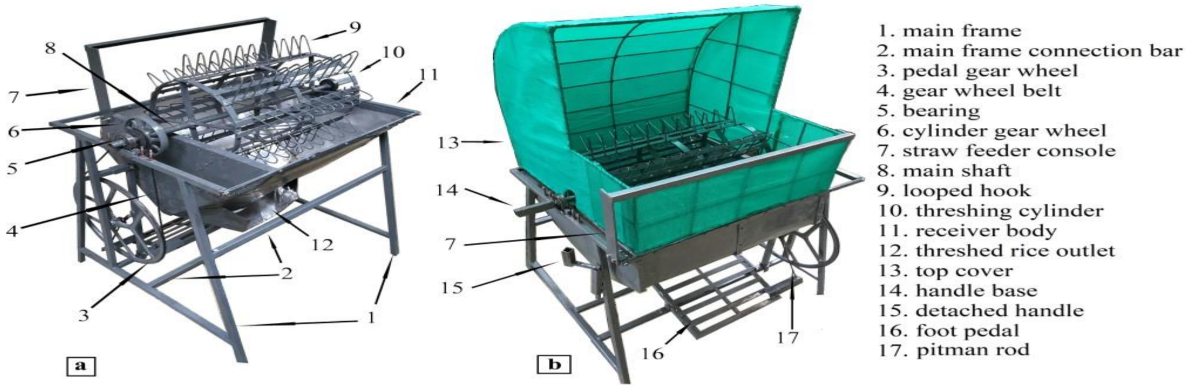

Figure 2. The front (a) and rear (b) view of the rice thresher showing different components of the machine.

The positive feedback received from the farmer in terms of reduced physical stress with the use of this thresher and reports from previous studies on reduction of farming cost through mechanization is suggestive of greater benefit to farmer in relation to physical well-being and cost effectiveness of using compatible tools (Singh and Devi 2016). In the northeast region of India mechanization is at nascent stage but is much needed to improve food production. Therefore, thorough research needs to be done in the process of developing farming tools to invent user-friendly and cost-effective tools.

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