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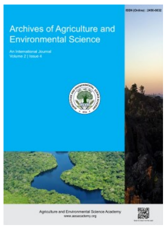

ORIGINAL RESEARCH ARTICLE

CrossMark

An investigation on the performance of rice threshing drums in the southwestern region of Bangladesh

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ABSTRACT

This study evaluated the performance indices of the locally developed rice-threshing drum in the Khulna region of Bangladesh. Threshing efficiency, throughput capacity, output capacity, threshing capacity and grain to straw ratio were assessed and data were analyzed using ANOVA as a statistical tool. The study involved the thresher with different engine horsepower capacities (25hp, 20hp, and 16hp). The variables of paddy were two stages of moisture content (14% referred as dry condition and 23% referred as wet condition), four different cutting heights of paddy (25-30, 30-35, 35-40 and 40-45 cm). The values for threshing efficiency, threshing capacity, output capacity, throughput capacity and grain to straw ratio in dry conditions ranged from 97.83 – 98.83%, 1700-2373 kg/hr, 27.75 -36.46 kg/hr, 930 – 1436 kg/hr and 1.21-1.54 respectively and in wet condition ranged from 96.15 – 97.79%, 1168-2167 kg/hr, 41.64 -49.99 kg/hr, 622 – 1280 kg/hr and 1.14-1.45, respectively. It was observed that with the increase in moisture content, cutting height and decrease in engine horsepower, there was a significant decrease ($p < 0.05$) in output capacity, threshing capacity, threshing efficiency and grain to straw ratio and vice versa. Therefore, the thresher used would be more useful by maintaining a proper combination of machine-crop parameters such as a moisture content of 14-15 %, an engine horsepower of 25 hp and a cutting height of 25-30 cm. Insights from this study can guide the development and adoption of improved paddy-threshing technologies in the region.

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INTRODUCTION

Rice (*Oryza sativa* L.) represents roughly two-thirds of the world's population's staple diet (Wynn, 2008). Rice accounts for up to 75% of the daily calorie consumption of people in various Asian countries, according to reports (FAO, 2001). Approximately 75% of Bangladesh's total land area and 80% of its irrigated land, which has remained relatively consistent over the previous three decades, is planted with rice, yielding 53.6 million tons of grain on 10.5 million hectares of land (BRKB, 2019). Rice will be the major food for 10 billion people by 2025, according to estimation, and demand will rise by 880 million tons (Rehal *et al*, 2017). Small-scale farmers produce about four-fifths of the world's rice, which is consumed locally (BRKB, 2019).
Despite the increasing agricultural production, the rice value chain continues to face significant qualitative and quantitative post-harvest losses. These losses can be attributed to inadequate post-harvest practices, particularly in the methods of

harvesting and threshing rice. Such practices result in substantial losses that hamper overall efficiency and food security. An estimated 30% of physical losses occur from the farm to the table (IRRI, 2015). At the national level, the post-harvest losses for Boro, Aus, and Aman were 12.29%, 12.18%, and 11.24%, respectively, from producer to retailer (Majumder *et al.*, 2016). At the farm level, the assessed total post-harvest losses of rice for the Aman, Boro, and Aus seasons were 9.49%, 10.51%, and 10.59%, respectively (Bala *et al.*, 2010). Applying suitable post-harvest practices, such as threshing and drying, is a must for raising the quality of rice (Mutungi *et al.*, 2020).

So, among post-harvest operations threshing is one of the most important operations. The removal or separation of grains from the panicles of stalks is called threshing. Traditionally, rice threshing was done manually, by hand beating, and bullock treading. However, manual threshing is labor-intensive, time-consuming, and can result in considerable grain losses. Panicles that are very dry or damp provide a particular issue (Rickman *et al.*, 2013). To address these challenges, various mechanical threshing methods have been developed. One common approach is using rice threshing machines, which are designed to efficiently separate the rice grains from the straw using rotating drums or paddles. These machines have significantly improved the efficiency of threshing operations, reducing labor requirements and minimizing grain losses. Moreover, innovations in rice threshing technology have led to the development of small-scale, locally adapted threshing machines suitable for use in diverse farming communities. These locally developed machines cater to the needs of smallholder farmers, who form a substantial portion of the global rice cultivation landscape. In Khulna, locally manufactured rice threshing drum are employed for threshing operation but damage percentage was quite high and output capacity was not high. The reasons behind are lack of proper knowledge about suitable machine-crop parameter. The quality of rice is determined by the use of suitable threshing techniques and the timely threshing is essential to reduce post-harvest losses (Agha, 2004). Threshing loss, damaged grains percent and power requirement are influenced by factors such as engine rpm, crop moisture content and variety (Asli-Ardeh *et al*, 2009).

The threshing efficiency, output capacity and grain damage of this rice thresher were tested at various degrees of concave clearance, cylinder peripheral speed, grain moisture, and feed rate (Dhananchezhiyan *et al.*, 2013). A study demonstrates the performance analysis of a rice thresher with several forms of paddy straw, including the use of various cylinder types, sieving mechanisms, and paddy analysis (Murthy *et al.*, 2019). Selection and advancement of rice threshers should consider threshing loss (threshing, scattering and breakage losses), versatility (operating conditions like moisture content), threshing rate (reduce overall output and labor requirement), portability, output quality, power source, ease of use (Amare *et al*, 2015).

However, the performance of these locally developed threshing drums often falls short in terms of efficiency, grain preservation, and labor requirements. It was crucial to establish a standardized power range for threshing. Valuable information was obtained, resulting in higher threshing efficiency, minimal grain loss through comprehensive and methodical studies on threshing parameters for rice thresher. The objective of this study was to carry out performance evaluation of rice threshing drum at two different moisture contents, three different engine power and four different cutting height. The study recommended the combination of machine-crop parameter by conducting thorough analysis which optimized the performance of the existing thresher to contribute the sustainable agricultural practices.

MATERIALS AND METHODS

Study location

The study was conducted at Dacope (sub-district), Khulna, Bangladesh. A locally developed rice threshing drum was used for the experiment.

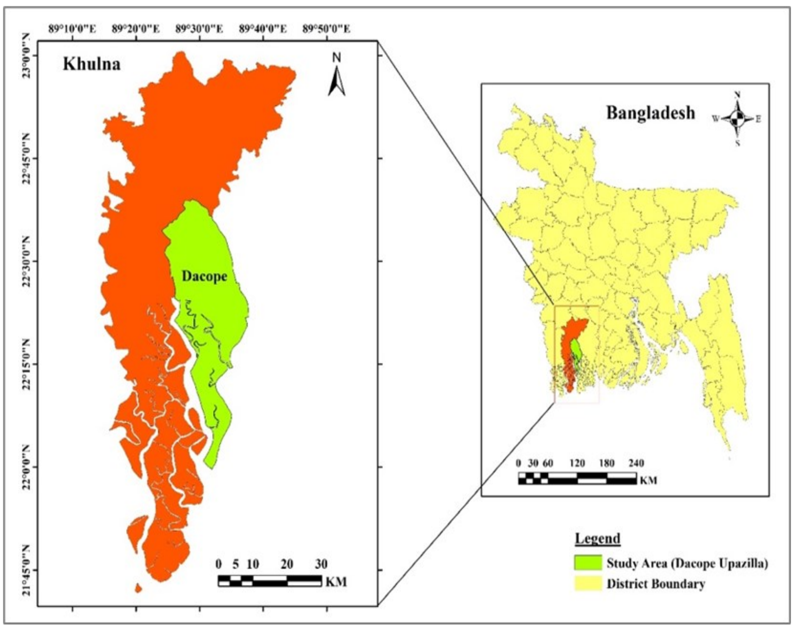


Figure 1. *Map of study area (Dacope, Khulna, Bangladesh).*

Machine description

For the investigation, three rice threshers with varying horsepower were chosen. The feed, threshing, blower, separation, and delivery units are the five fundamental parts of the thresher machine. Materials are moved more easily with the thresher's open axial-flow peg tooth threshing drum and throw-in feeding system. The threshing compartment operates based on the concept of impacts generated by numerous metallic bars and pegs positioned around its circumference.

Operation of the thresher

The grain-containing crop mass is brushed across a screen, and chopped material for animal feed is released along with the straws. The material is threshed by spiraling it through a closed cylindrical case and hammering it with a set of pegs to remove the grains. The fine straw and grains are finally released via the perforated concave and roll over the inclined sheet metallic pan. The straw is then transported to the straw outlet where it is released. The 16, 20, and 25 horsepower engines, which have an average speed of 2100, 3200, and 4100 rpm, respectively, power the thresher. The engine's power is transferred to the threshing drum using a pulley and V-belt system.

Sample preparation

Freshly harvested BRRI11 and BRRI10 varieties of rice plants were obtained from farmers. The samples were separated according to the cutting height of the paddy. Paddy plants of 25-30 cm, 30-35cm, 35-40cm and 40-45 cm cutting height were taken for the study. Moisture content was 23% in the initial stage of harvesting. The plants were then subsequently spread out in thin layers within a shed to undergo drying until reaching the desired moisture levels, as determined by a digital moisture meter and after drying the moisture content was reduced to 14%. The paddy with this two-moisture level was then prepared for threshing.

Procedure

The machine's hopper receives the harvested paddy via a throw-in mechanism. The thresher works by axially moving the material until the straw is ejected through the delivery chute. Most of the grain is threshed during the initial impact. By circulating air current through the feed, the blower separates the grain from the chaff and other lighter debris. When grain is threshed, it passes through the concave's apertures along with certain pollutants like leaves and tiny pieces of straw. Large contaminants are then filtered out of the screen.

Performance evaluation parameters

The performance assessment of the acquired rice thresher was directed in the Dacope Upazilas of Khulna district, Bangladesh. To change the thresher's speed, the engine was turned to the required drum speed. The paddy was fed into the hopper and the amount of threshed paddy was gathered from the discharge chute and the duration between the feeding and threshing processes was measured and documented using a stopwatch. The unthreshed paddy and straw were gathered and weighed individually. The performance of the thresher was assessed using metrics such as output capacity, threshing efficiency, cleaning efficiency, mechanical kernel damage, and scatter losses. Performance assessment of the rice thresher was determined using the following relation (Khan *et al.*, 2007; Ndirika & Onwualu, 2016)

Output capacity (OC kg/h): This can be referred as the thresher's ability to thresh a specific amount of paddy per unit time.

$$OC = \frac{Q_t}{T} \quad \text{.........................(i)}$$

Where; Qt = Quantity of threshed material that passed through the paddy collector, kg; T = Time taken to complete the threshing operation, min

Grain-straw ratio (GSR): Grains were separated carefully from the stacked bundle of paddy based on selected length and weighted. The grain to straw ratio was calculated as follows:

$$GSR = \frac{GW}{SW} \quad \text{.........................(ii)}$$

Where; GW=Grain weight, kg; SW= Straw weight, kg

Throughput capacity (TC kg/h): Unthreshed harvested crop was weighted and fed into the thresher at normal running condition and threshing time was recorded. Throughput capacity was calculated as follows:

$$TC = \frac{WC}{T} \times 60 \quad \text{.........................(iii)}$$

Where; WC = Weight of harvested crop (unthreshed), kg; T = Recorded time, min

Threshing capacity (T_hC kg/h): Total threshed grain (whole and damaged) collected from the main outlet was weighted and threshing time was recorded. Threshing capacity was calculated as follows:

$$ThC = \frac{WG}{T} \times 60 \quad \text{.........................(iv)}$$

Where; WG=Weight of total output grain, kg; T=Recorded time, min

Threshing efficiency (TE %): Total grain input and unthreshed grain from the entire outlet was weighted. Threshing efficiency was calculated as follows:

$$TE = \frac{WI - WC}{WI} \times 100 \quad \text{..................(v)}$$

Where; WI = Weight of total grain input, kg; WC = Weight of unthreshed crop, kg

Statistical analysis

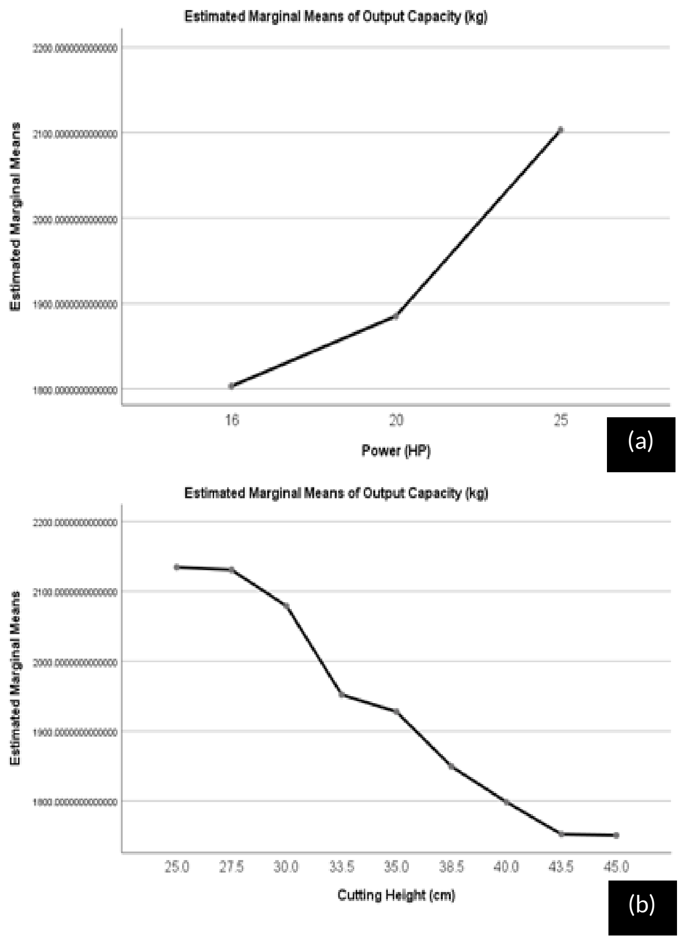
In SPSS, the General Linear Model (GLM) univariate procedure was used to analyze the single and combined effects of the independent variables on the dependent variable.

RESULTS AND DISCUSSION

Effect of paddy cutting height and engine horsepower on output capacity in dry and wet condition

The variable power and cutting height had significance in the case of dependent variable output capacity (dry condition), having a p-value of 0.000(<0.05) and 0.004(<0.05) respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 0.943(>0.05). Figure 2 shown the impact of cutting height and engine horsepower on thresher output capacity in dry conditions. In Figure 2(a), a change in output capacity (dry condition) in response to power was shown, which indicated a positive relationship between them. The results show that, as the moisture contents of paddy increased, the output capacity decreased. A similar trend was observed by (Dhananchezhiyan *et al.*, 2013). When the thresher is equipped with a more powerful engine and operated at a higher speed, it can work more efficiently and effectively. The increased horsepower and speed allow the machine to handle larger quantities of paddy thus resulting in higher output capacity per hour which is also reported by (Dangora *et al.*, 2023). Besides, in Figure 2(b), a change in output capacity (dry condition) in response to cutting height was shown, which indicated a negative relationship between them. The shortest cutting height yields the highest output capacity per hour. Therefore, minimizing the cutting height is crucial to achieving maximum output capacity, regardless of the moisture content of the paddy. As the cutting height is raised, the thresher's ability to effectively separate the grains diminishes, leading to a reduction in output capacity. On the other hand, in Figure 2(c), changes in output capacity (dry condition) in response to different cutting heights under different powers were shown. It indicated that the overall effect of power and cutting height on the output capacity (dry condition) followed a positive trend.

The variable horsepower and cutting height had significance in case of dependent variable output capacity, having a p-value of 0.000(<0.05) and 0.001(<0.05) respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 1.000(>0.05) (Table 1). A change in output capacity in wet condition (23% MC) in response to power and cutting height was shown respectively, which is similar as dry condition. On the other hand, changes in output capacity in response to different power under different cutting heights also follows the same pattern as dry conditions.



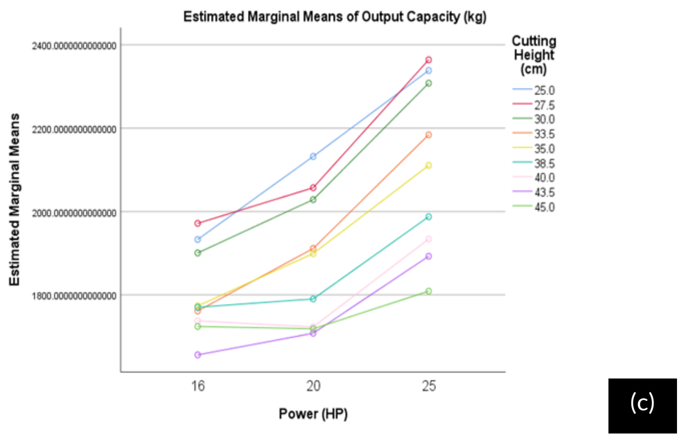


Figure 2 (a-c). *Effect of paddy cutting height and engine horsepower on output capacity in dry condition (14-15% MC).*

Table 1. ANOVA Results of cutting height and engine horsepower on output capacity in wet condition (23% MC).

Tests of between-subjects effects					
Dependent variable: Output capacity (kg)					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	2730795.270[a]	26	105030.587	8.394	.001
Intercept	88988923.855	1	88988923.855	7111.900	.000
Power	1283878.087	2	641939.043	51.303	.000
Cutting height	1207492.285	8	150936.536	12.063	.001
Power * Cutting height	26158.243	16	1634.890	.131	1.000
Error	112614.111	9	12512.679		
Total	101635922.378	36			
Corrected total	2843409.381	35			

a. R Squared = .960 (Adjusted R Squared = .846)

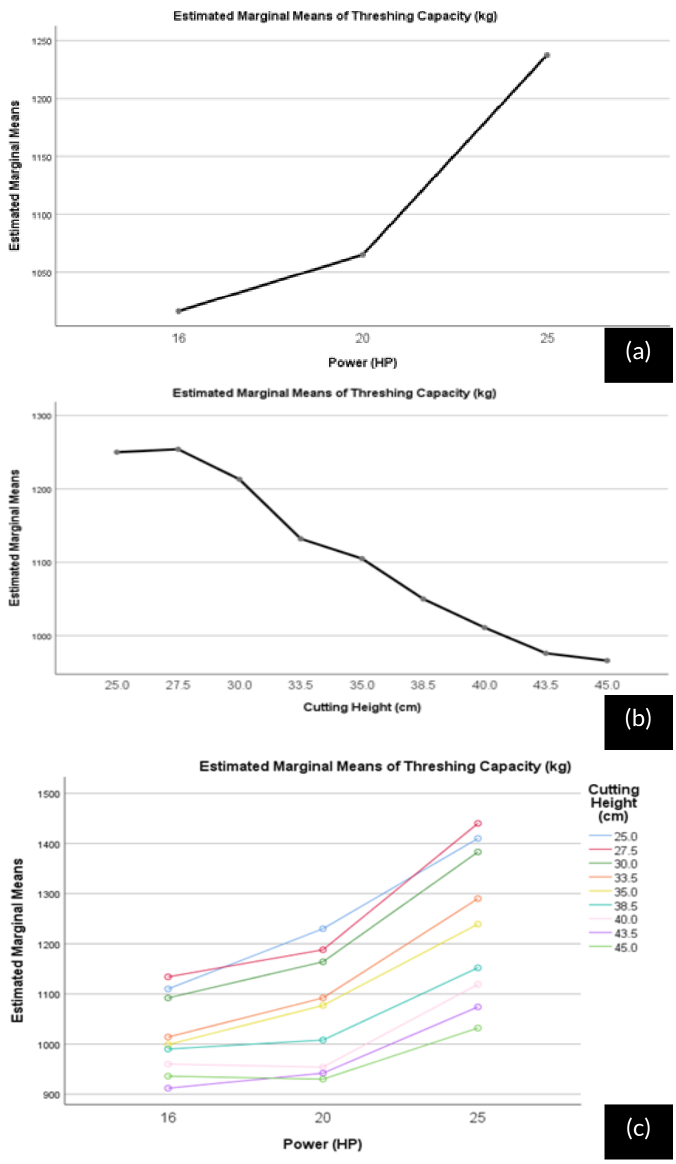


Figure 3 (a-c). *Effect of paddy cutting height and engine horsepower on threshing capacity in dry condition (14-15% MC).*

Effect of paddy cutting height and engine horsepower on threshing capacity in dry and wet condition

The variable horsepower and cutting height had significance in case of dependent variable threshing capacity, having a p-value of 0.000(<0.05) and 0.002(<0.05) respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 0.956(>0.05). In Figure 3(a), a change in threshing capacity in dry condition (14% MC) in response to power was shown, which indicated a positive relationship between them. Besides, In Figure 3(b), a change in threshing capacity in response to cutting height was shown, which indicated a negative relationship between them. On the other hand, In Figure 3(c), changes in threshing capacity in response to different power under different cutting heights were shown. It indicated that the overall effect of power and cutting height on the threshing capacity in dry condition (14% MC) followed a positive trend. Empirical evidence indicates that paddy containing around 14-15% moisture content, categorized as dry paddy, delivers the highest threshing capacity per hour. This moisture level appears to strike the optimal balance, facilitating efficient threshing without the complications associated with excessive moisture. The highest capacity noted for the rice thresher was remarkably higher than the maximum value (187.5kg/h) at moisture content of 16%, machine speed of 750 rpm stated by (Adefidipe & Adetola, 2022) and the alteration in this result might be due to the low energy provided to the system by the power source.

The variable horsepower and cutting height had significance in the case of the dependent variable threshing capacity in wet conditions (23% MC), having a p-value of 0.000(<0.05) and 0.000(<0.05), respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 1.000(>0.05) (Table 2). Change in threshing capacity in response to power and cutting height indicates a positive and a negative relationship respectively between them. On the other hand, changes in threshing capacity in response to different power under different cutting heights indicates that the overall effect of power and cutting height on the threshing capacity in wet conditions (23% MC) followed a positive trend. However, when dealing with paddy that possesses higher moisture content (referred to as wet paddy), the threshing capacity per hour is diminished. This is attributed to the necessity for increased impact force in order to achieve effective threshing. Consequently, a greater proportion of grains remain un-threshed in such conditions.

Table 2. ANOVA Results of cutting height and engine horsepower on threshing capacity in wet condition (23% MC).

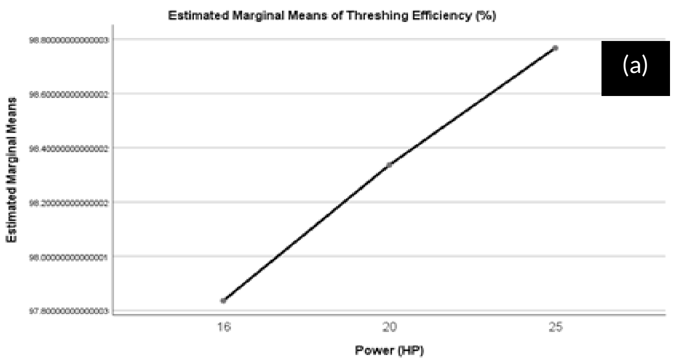
Tests of Between-Subjects Effects					
Dependent variable: Threshing capacity (kg)					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected model	1155188.000[a]	26	44430.308	8.678	.001
Intercept	27902361.600	1	27902361.600	5449.680	.000
Power	535593.600	2	267796.800	52.304	.000
Cutting height	524840.000	8	65605.000	12.813	.000
Power * Cutting height	9214.000	16	575.875	.112	1.000
Error	46080.000	9	5120.000		
Total	32181624.000	36			
Corrected total	1201268.000	35			

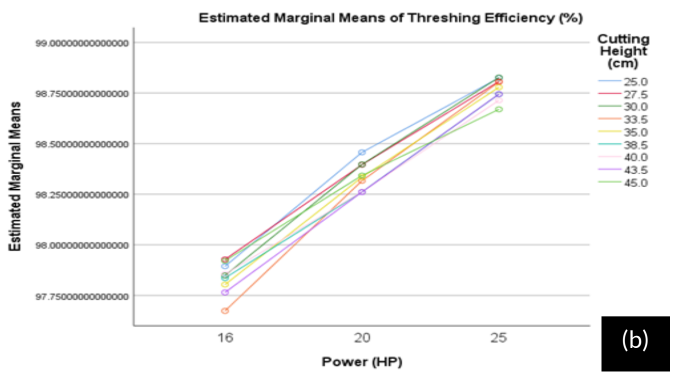
a. R Squared = .962 (Adjusted R Squared = .851)

Effect of paddy cutting height and engine horsepower on threshing efficiency in dry and wet condition

The variable horsepower had significance in the case of dependent variable threshing efficiency in dry conditions (14% MC), having a p-value of 0.000(<0.05) but cutting height as well as the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 0.217(>0.05) and 0.708(>0.05) respectively. In Figure 4(a), a change in threshing efficiency (dry condition) in response to power was shown, which indicated a positive relationship between them. A thresher equipped with a more powerful engine can provide increased torque and energy to drive the threshing mechanisms. This leads to more effective and efficient threshing, especially when processing a higher volume of crop material or when dealing with challenging conditions (such as wet or densely packed paddy). With higher engine horsepower, the thresher can maintain optimal operational speed and maintain the necessary force to separate grains from husks, resulting in improved efficiency. Threshers with lower engine horsepower might struggle to provide the required force and speed for efficient separation. This can result in incomplete threshing and reduced efficiency, particularly when handling larger quantities of crop or when processing materials that require greater force for separation. A similar outcome was observed by Dangora *et al.* (2023) & Ani *et al.* (2020). Besides, in Figure 4(b), a change in threshing efficiency (dry condition) in response to cutting height was shown, which indicated a negative relationship between them. Lower cutting height results in higher threshing efficiency because the thresher has better access to the grains, making it easier to separate them from the husks or chaff. A lower cutting height facilitates better engagement and contact between the crop and the threshing mechanism, leading to improved separation and higher efficiency. Increasing the cutting height means less material enters the thresher. This can lead to lower threshing efficiency because there is reduced contact between the thresher blades and the grains. The separation process becomes less effective, and the thresher may struggle to achieve complete separation, resulting in a lower efficiency level. On the other hand, in Figure 4(c), changes in threshing efficiency (dry condition) in response to different cutting heights under different powers were shown. It indicated that the overall effect of power and cutting height on the threshing efficiency (dry condition) followed a positive trend.

The variable horsepower and cutting height had significance in case of the dependent variable threshing efficiency in wet conditions (23% MC), having a p-value of 0.000(<0.05) and 0.002 (<0.05) respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 0.591(>0.05) (Table 3). Change in threshing efficiency in response to power and cutting height indicates a positive and a negative relationship respectively between them. On the other hand, changes in threshing efficiency in response to different power under different cutting heights indicate that the overall effect of power and cutting height on the threshing efficiency in wet conditions (23% MC) followed a positive trend.





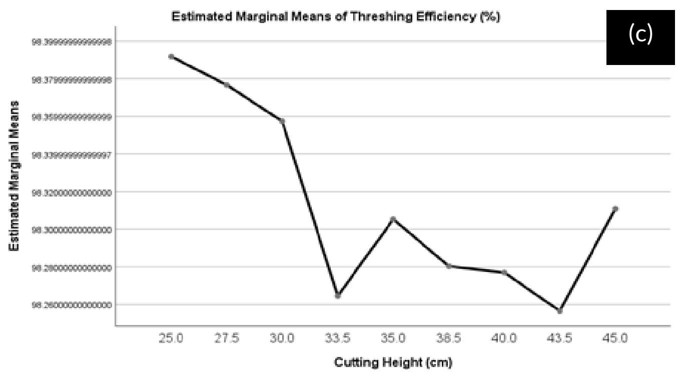


Figure 4 (a-c). *Effect of paddy cutting height and engine horsepower on threshing efficiency in dry (14-15% MC) condition.*

Table 3. ANOVA Results of cutting height and engine horsepower on threshing efficiency in wet condition (23% MC).

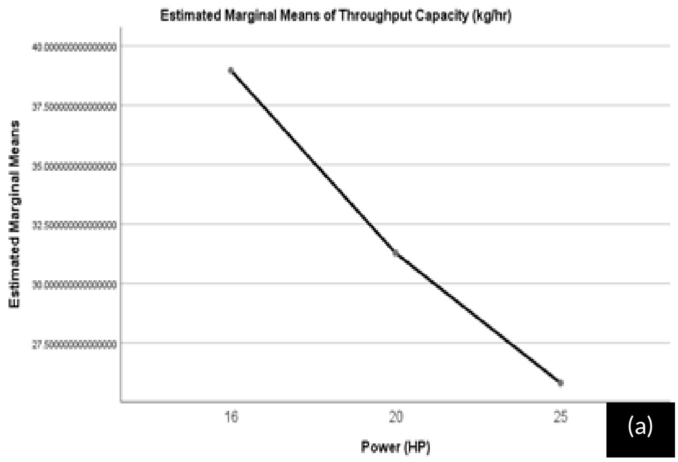
Tests of Between-Subjects Effects					
Dependent Variable: Threshing Efficiency (%)					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected model	9.224[a]	26	.355	16.523	.000
Intercept	305896.975	1	305896.975	14246082.107	.000
Power	6.542	2	3.271	152.332	.000
Cutting height	1.406	8	.176	8.185	.002
Power * Cutting height	.310	16	.019	.901	.591
Error	.193	9	.021		
Total	339883.047	36			
Corrected total	9.418	35			

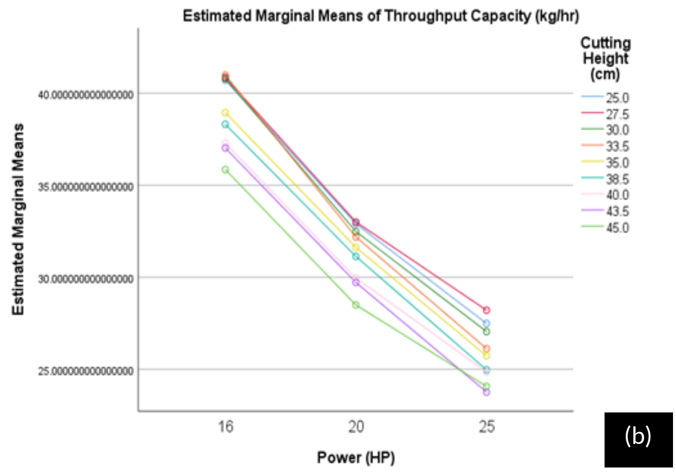
a. R Squared = .979 (Adjusted R Squared = .920)

Effect of paddy cutting height and engine horsepower on throughput capacity in dry and wet condition

The variable horsepower and cutting height had significance in the case of dependent variable throughput capacity in dry conditions (14% MC), having a p-value of 0.000(<0.05) and 0.000 (<0.05) respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 0.930(>0.05). Change in throughput capacity in dry conditions (14% MC) in response to power and cutting height indicates a negative relationship respectively between them in Figure 5(a) and 5(b). A higher engine horsepower allows the thresher to process more crop material in a given amount of time, leading to increased throughput capacity and reduced un-threshed grain per hour. On the other hand, lower engine horsepower results in reduced throughput capacity and increased un-threshed grain per hour. Moreover, In Figure 5(c), changes in throughput capacity in dry conditions in response to different power under different cutting heights also indicates that the overall effect of power and cutting height on throughput capacity followed a negative trend.

The variable horsepower and cutting height had significance in case of dependent variable throughput capacity in wet conditions (23% MC), having a p-value of 0.000(<0.05) and 0.000 (<0.05) respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 0.970(>0.05) (Table 4). A change in throughput capacity (wet condition) in response to power was shown, which indicated a negative relationship between them. A change in throughput capacity (wet condition) in response to cutting height was shown, which indicated a negative relationship between them too. On the other hand, changes in throughput capacity (wet condition) in response to different cutting heights under different powers were shown. It indicated that the overall effect of power and cutting height on the throughput capacity (wet condition) followed a negative trend.





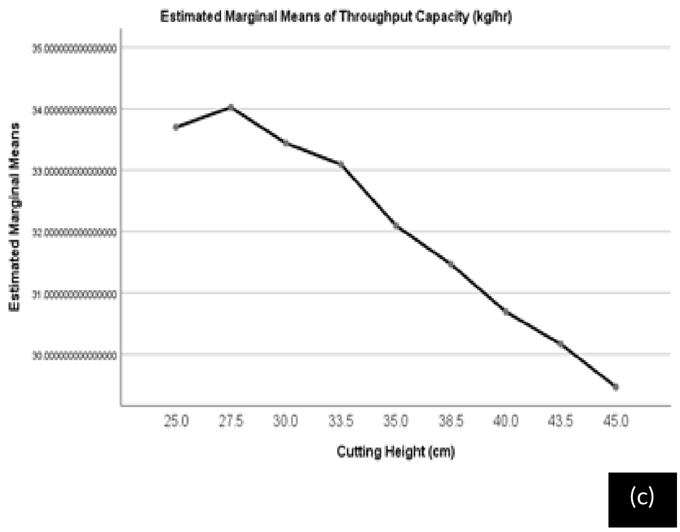


Figure 5 (a-c). *Effect of paddy cutting height and engine horsepower on throughput capacity in dry (14-15% MC) condition.*

Table 4. ANOVA Results of cutting height and engine horsepower on throughput capacity in wet condition (23% MC).

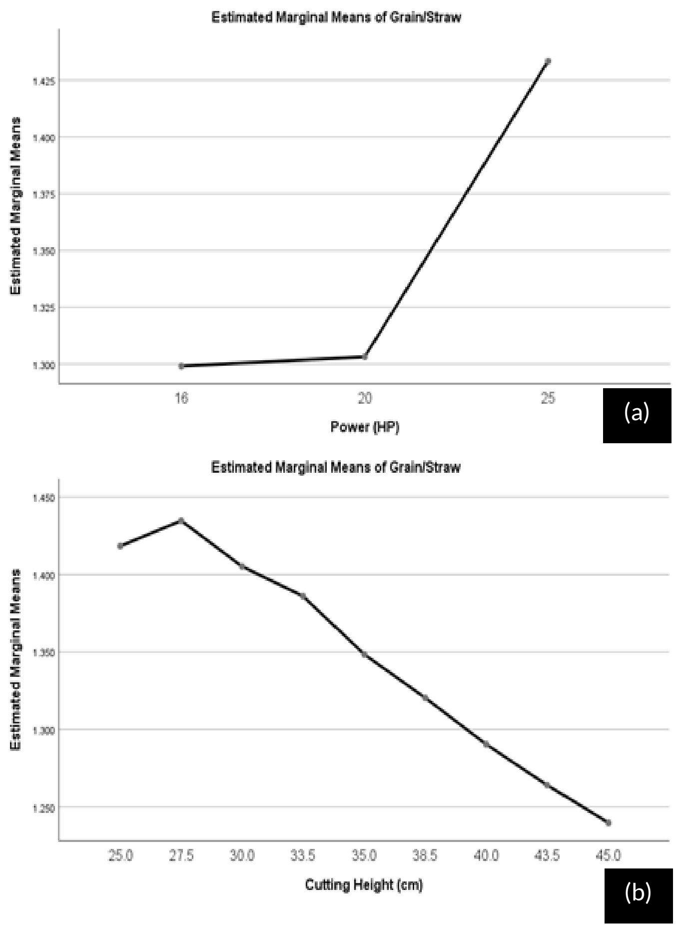
Tests of Between-Subjects Effects					
Dependent variable: Throughput capacity (kg/hr)					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	254.755[a]	26	9.798	7.757	.002
Intercept	67463.225	1	67463.225	53407.621	.000
Power	83.615	2	41.808	33.097	.000
Cutting height	156.034	8	19.504	15.441	.000
Power * Cutting height	6.916	16	.432	.342	.970
Error	11.369	9	1.263		
Total	75298.564	36			
Corrected total	266.124	35			

a. R Squared = .957 (Adjusted R Squared = .834)

Effect of paddy cutting height and engine horsepower on grain to straw ratio in dry and wet condition

The variable horsepower and cutting height had significance in case of dependent variable grain-straw ratio in dry condition (14% MC), having a p-value of 0.000(<0.05) and 0.000(<0.05) respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 0.925 (>0.05). Change in grain-straw ratio in dry condition (14% MC) in response to power and cutting height indicates a positive and a negative relationship respectively between them in Figure 6(a) and 6(b). This is because, at a higher cutting height, more of the plant's straw portion will be included in the harvested material. This can lead to a higher proportion of straw in the harvested mixture and potentially reduce the grain-to-straw ratio. Harvesting paddy at a lower cutting height means that less straw will be included in the harvested material, resulting in a higher proportion of grains. This can increase the grain-to-straw ratio and improve the yield of valuable rice grains. On the other hand, In Figure 6(c), changes in grain-straw ratio in response to different power under different cutting heights also indicate that the overall effect of power and cutting height on grain-straw ratio followed a positive trend.

The variable horsepower and cutting height had significance in the case of the dependent variable grain-straw ratio in wet condition (23% MC), having a p-value of 0.000(<0.05) and 0.000 (<0.05) respectively. On the other hand, the combination of power and cutting height (Power * Cutting Height) wasn't significant as the p-value is 0.944(>0.05) (Table 5). Change in grain-straw ratio in wet condition (23% MC) in response to power and cutting height indicates a positive and a negative relationship respectively between them. On the other hand, changes in grain-straw ratio in response to different power under different cutting heights also indicates that the overall effect of power and cutting height on grain-straw ratio followed a positive trend. Paddy grains with high moisture content can become sticky. This stickiness can cause the grains to clump together, making it more difficult for the thresher to separate the grains from the straw. As a result, more straw might remain attached to the grains, leading to a lower grain-to-straw separation efficiency.



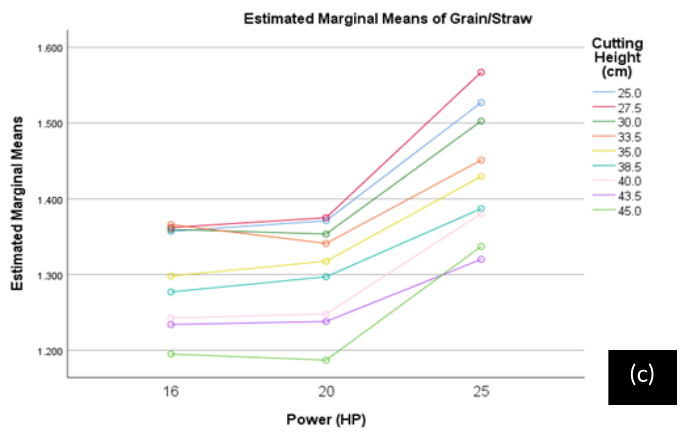


Figure 6 (a-c). *Effect of paddy cutting height and engine horsepower on grain to straw ratio in dry (14-15% MC) condition.*

Table 5. ANOVA Results of cutting height and engine horsepower on grain-straw ratio in wet condition (23% MC).

Tests of Between-Subjects Effects					
Dependent variable: Grain/Straw					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected model	.250[a]	26	.010	9.686	.001
Intercept	52.340	1	52.340	52673.890	.000
Power	.109	2	.055	54.850	.000
Cutting height	.122	8	.015	15.320	.000
Power * Cutting height	.006	16	.000	.408	.944
Error	.009	9	.001		
Total	58.474	36			
Corrected total	.259	35			

a. R Squared = .965 (Adjusted R Squared = .866)

Conclusion

The acquired rice thresher was successfully assessed based on the variable's moisture content, paddy cutting height and engine horsepower. In total experiment, threshing efficiency remained consistently high at 96-98%, it therefore shows there was only a little un-threshed rice paddy. Experimental runs indicate, lower cutting heights improve separation efficiency, boosting productivity, while higher engine horsepower enhances overall performance. Adjusting thresher settings based on moisture levels is vital, with wet conditions requiring increased impact force and dry conditions needs gentler treatment to prevent grain breakage. Additionally, both high moisture content and higher cutting heights decrease the grain-to-straw ratio, impacting grain yield and straw quality. The findings indicated that the moisture content, engine horsepower, and cutting height of paddy had a significant impact on threshing efficiency, output capacity, throughput capacity, threshing capacity, and grain to straw ratio under both dry and wet conditions.

Declarations

Author contributions: Conceptualization, A.C.K and J.B.; methodology, M.S.A.; software, S.N.; validation, S.N., G.T.U. and M.S.A.; formal analysis, A.H.; investigation, M.T.H.; resources, S.N.; data curation, G.T.U.; writing—original draft preparation, J.B.; writing—review and editing, A.H.; visualization, M.T.H.; supervision, J.B.; project administration, A.C. K.; funding acquisition, A.C.K. All authors have read and agreed to the published version of the manuscript. Use this format to write authors' contributions and write authors abbreviations in place of the full name of authors.

Conflict of interest: The authors declare no conflict of interest.

Ethical approval: Not applicable.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

Supplementary data: Not available.

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