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Development and Performance Evaluation of Engine Driven Finger Millet Thresher

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ABSTRACT

Finger millet is the sixth most important cereal crop in Ethiopia in total area and production. Nonetheless, the unavailability of efficient threshing machine is the most serious constraints in finger millet production in Ethiopia. Traditional method of threshing is characterized as time consuming, wasteful, associated with excessive losses, and has high drudgery. Therefore, engine driven finger millet thresher was designed, fabricated, and evaluated. Performance tests of the fabricated finger millet thresher were conducted at three different levels of cylinder speed (600.00, 700.00, 800.00 rpm) and three levels of feeding rates (6.00, 9.00, 12.00 kg/min) at constant moisture content. The results indicated that the mean threshing capacity, threshing efficiency, cleaning efficiency, Threshing loss, and fuel consumption are 311.95 kg/hr, 98.63%. 98.13 %, 2.75 % and 63.06 ml/min respectively. Based on the performance evaluation results, it is concluded that the developed thresher can be effectively and economically used in small-scale Farmer.

Keywords: Finger Millet; Feeding Rate; Drum Speed; Threshing Capacity; Threshing Efficiency; Cleaning Efficiency; Fuel Consumption; Least Significant Difference; Threshing Loss; Coefficient of Variation.

1. Introduction

Finger millet (*Eleusine coracana* (L.) Gaertn) is an important cereal crop in the semi-arid and tropical regions of the world. The name finger millet is derived from the appearance of spikes or fingers, which are arranged and appear like human fingers. Finger millet grown extensively in various regions of India and Africa, constituting as a staple food for a large segment of the population in these countries (Satyavathi et al., 2021). Compared with other major cereals such as rice, wheat, and barley, it is relatively drought-tolerant due to its C_4 photosynthesis system and adaption to grow under harsh and marginal agro-ecologies (Gebreyohanne et al., 2021). The finger millet grains contain a high amount of calcium among all cereals which is an essential macro-nutrients necessary for growing children, pregnant women, and the elderly (Pawase et al., 2019).

Finger millet is the sixth most important cereal crop in Ethiopia in terms of total area coverage and production. About 1,913,024 smallholder farmers grown finger millet on about 480,343 ha of land, and produced 12,030164.02 quintals in Meher season, in Ethiopia (CSA, 2021). The annual finger millet area coverage in 2020/21cropping season, in Oromia Region was estimated at 97,267.88 hectares, with a total production of 2 .2 million quintals. In Ethiopia, finger millet production increased from year to year, however threshing of finger millet is still done by traditional methods. Finger millet threshing is one of the most serious constraints for its production in Ethiopia (Tsehaye and Kebebew 2002; Erenso et al., 2009). Gebreyohannes et al. (2021) reported that threshing operation is a tedious and labor-intensive operation in finger millet production. The farmers use draught animals or labor to thresh and wind for winnowing. Asres et al. (2025) noted that traditional threshing currently requires multiple days of work, extended hours, and the involvement of several cattle, along with both paid and unpaid labor. Although cleaning is less time-consuming, it still relies heavily on manual labor, often involving family members. Notably, child labor participation is prevalent across all processes, with children aged 5–15 years old constituting 46.4% of the workforce, of which a significant portion is female. Efforts were done in Ethiopia to import different types of threshers, but such threshers are of high costs, which are beyond the reach of farmers, difficult to maintain and repair, lack of spare parts, and not amenable to local conditions. A multi crop thresher was developed in FARC (Fadis Agricultural Research Center) this multi crop thresher was evaluated at BAERC (Bako Agricultural Engineering Research Center). They reported that this FARC multi crop thresher had finger millet threshing capacity of 82.74 kg/hr low cleaning efficiency (48.00%) and high losses (7.14%) (Gelgelo et al., 2020). Therefore, this research project is aimed at designing, fabricating, and performance evaluation of an appropriate and affordable, finger millet thresher for small-scale farmers in our country.

1.1. Study Objectives

General Objective: To design, construct and evaluate the performance of engine driven finger millet thresher.

Specific Objectives: (1) To design engine driven finger millet threshing machine. (2) To fabricate engine driven finger millet threshing machine. (3) To evaluate the performance of the fabricated finger millet threshing machine.

2. Materials and Methods

2.1. Materials

The finger millet threshing machine is constructed using a manufacturing procedure which by using materials that are locally available like different sizes of sheet metal, angle iron, square pipe.

2.2. Method

2.2.1. Study Area

The prototype of finger millet threshing machine was designed and constructed at Jimma Agriculture Engineering Research Center. Jimma Agriculture Engineering Research Center located in Jimma zone, Oromia regional state, in southwest Ethiopia.

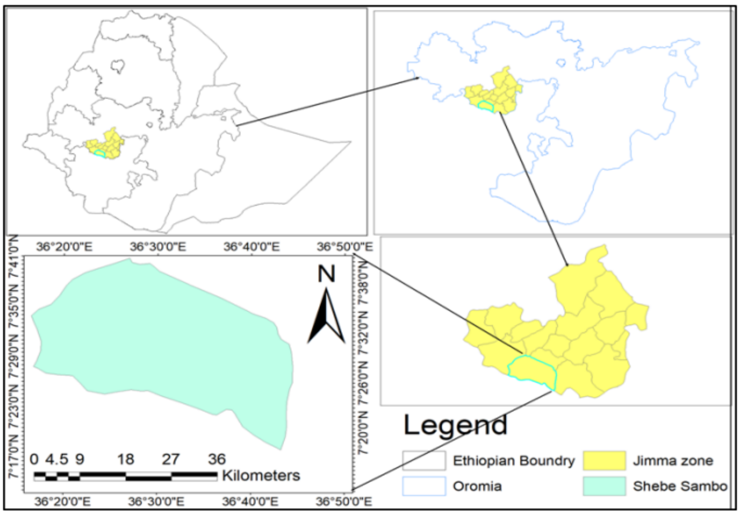

Figure 1. Map of Study Area

Geographically, JAERC is found 1550 meters above sea level (m.a.s.l.) and is located between 8° 24' 0" and 70 40' 00" North and 360 49' 59.9'East, 350km from Addis Ababa. The performance of the machines was evaluated at

Shabe Sombo district, Jimma zone, Oromia regional state based on the potential areas in finger millet production. Geographically Shabe Sombo is located at 90 0 10' 41.5" and, 4200 15' 27.3" North of latitude and East longitude respectively, with an elevation of 1274 meters above sea level,42 km from Jimma town.

2.3. Design Consideration

➢ The materials used for the construction of the thresher were affordable and easily available in the local market.

➢ Design parameters included physical and frictional properties of grain, the peripheral speeds of the cylinder and the fan, and the feed rate of the thresher.

➢ The frame of the machine was designed based on Euler's column assumptions to ensure all possible forms of failure that could occur on the frame.

➢ The height of the machine was selected depending on the agronomical factor.

➢ The performance of the machine was dependent on the speed of drum cylinder and feed rate

2.4. Description of the machine Components

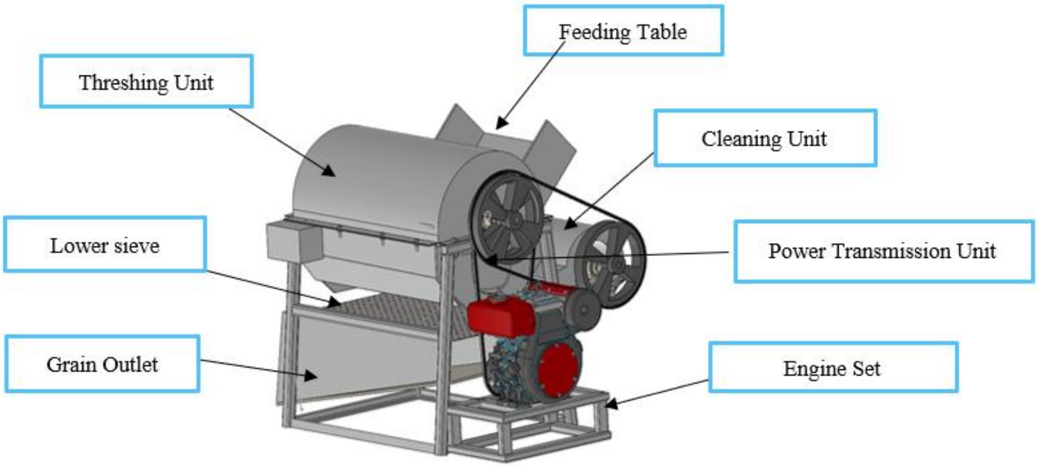

Figure 2. Design of developed thresher machine

2.4.1. Frame

The length of the frame was selected based on the design of the components mounted on it. The width of the frame was determined by the overall width of the threshing cylinder. The height of the frame was selected based on the position of the threshing cylinder, the blower, the sieve, and the mean height of the operator. The trapezium shaped frame was made of 50.00 mm x 50.00 mm x 4.00 mm MS square hollow section with dimensions 500 mm at its top in the vertical position , and 920 mm height for stability, the legs extend out at the end the legs at the end of the leg angle iron 50 mm x 50 mm x 4. mm welded with dimensions 500 mm × 920 mm at its bottom and left and right side 50 mm x 50 mm x 4 mm.

2.4.2. Feeding table and upper cover

The hopper has rectangular opening of 480 mm in length and 200 mm wide. The upper cover is designed to cover the upper section of the threshing drum and provide support for the feed hopper. Constructed from a 1.5 mm thick mild steel sheet of 835 mm by 450 mm, the upper cover is shaped by rolling into a half-cylinder with both sides bent by 50 mm. Holes were drilled to bolt to the lower cover of the threshing drum and the frame. A faceplate, marked and cut to a diameter of 35 mm, is divided into two halves and welded to either side of the cylinder, creating space for the shaft to pass through

2.4.3. Threshing unit

The threshing drum consisted of a wire loop type cylindrical threshing drum through which a shaft is to be passed. The threshing cylinder drum is made from 2.5mm thick sheet metal with a diameter of 400mm and a length of 800mm, incorporating a wire loop of 42 loops, a shaft diameter of 30mm, and 4 pieces of chaff thrower. The wire loops were securely attached to the drum cylinder using welding techniques, and they were strategically positioned in a staggered arrangement. These loops were made from a mild steel round bar with a diameter of 10 mm, chosen for its strength and durability. The decision to set the height of the loops at 60mm was carefully made, taking into account the necessary clearance between the drum and the concave. Four pieces of chaff thrower, each measuring 60mm in length and 90mm in width, made from 3mm sheet metal and welded onto the threshing cylinder in alignment with the chaff outlet, efficiently direct and expel chaff to the exterior, ensuring effective separation during the threshing Process.

2.4.4. Concave

A concave structure was constructed using a 2.5 mm thick mild steel sheet measuring 820 mm in length and with a diameter of 450 mm. Regularly spaced holes, each with a diameter of 4 mm and positioned 50 mm apart, were marked and drilled along the length of the sheet. To ensure easy discharge of grains, the diameter of the chosen equipment was made 20% larger than the calculated equivalent diameter of the finger millet seed. The concave is horizontally attached to the upper concave cover and lower cover of the concave using a nut and bolt arrangement to allow easy opening when necessary. The lower concave cover is constructed from a 1.5 mm thick mild steel sheet measuring 835 mm by 400 mm and both sides are bent by 50 mm. For chaff throwing, the lower had a rectangular opening of 150 mm in length and 100 mm in height.

2.4.5. Cleaning unit

A centrifugal blower was constructed from a Sheet metal of 1.50 mm thickness. It was attached on a shaft with a diameter of 25 mm and roller bearings were used to support. There were four rotational blades with curved peripheries on the blower assembly. The blower housing is used as both a blower cover and a direction of the air current toward the straw output. Fan housing was made with 1.5 mm metal sheet. It was 250mm in diameter and 800mm long, and it was below the hopper.

2.4.6. Lower sieve

According to Humphred, (2017) for easy discharge of grains the chosen diameter was made 20 % larger than the calculated equivalent diameter of the seed. The fabricated sheet metal measuring 820 mm in length and 500 mm in width was drilled with 4mm diameter hole and horizontally attached to frame using bolt and nut.

2.4.7. Grain Outlet

Grain outlet was designed based on the frictional properties of grains with grains. The rectangular shaped 1.5mm thickness MS sheet of 860×500 mm was weld at bottom of lower sieve supporter angle at 30° inclined manner along sieve to collect all the grains from the slotting sevie and direct into a receiver.

2.5. Working Principle of the Machine

The finger millet thresher machine consisted of three main units: a power unit, a threshing unit (drum and concave), and a cleaning unit (sieve and centrifugal fan). The threshing drum shaft rotated with the help of bearings and provided drive to the shaft of the cleaning chamber through belts and pulleys. The harvested finger millet grain panicles were fed into the threshing device, consisting of the threshing drum and concave, through the hopper and separated from the bulk of straw with the help of a wire loop type drum. The bulk of the grain fell through the concave grid into the cleaning unit, which consisted of sieves for separating grain from impurities and a centrifugal fan that blew air into the sieves. The clean grain entered the grain-collecting device through the grain out outlet.

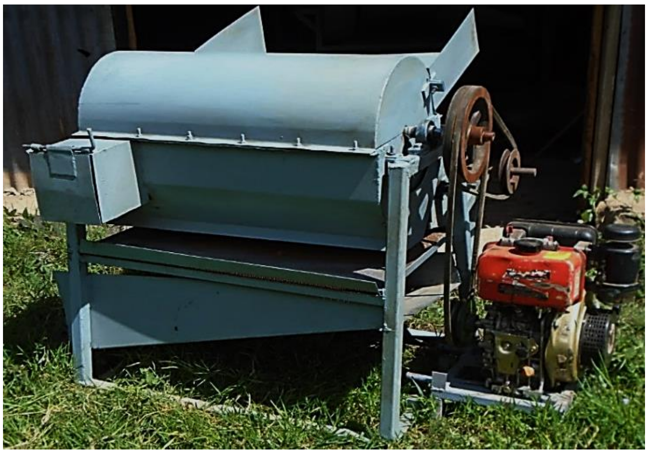

Figure 3. Picture of a developed prototype of a finger millet thresher

2.6. Performance Evaluation of finger millet thresher

The performance of the machine was evaluated from the data collected during, before, and after testing. The data were collected from field and laboratory tests based on the measurement or test required. The data collected included crop parameters (Moisture content, Grain –straw ratio)) and machine performance (threshing capacity, threshing efficiency, cleaning efficiency, threshing loss, and fuel consumption).

2.6.1. Moisture content

The moisture content of finger millet grain was determined by using the standard hot air oven method using the following formula (Patel et al. 2022).

$$M_c = \frac{W_i - W_f}{W_f} \times 100 \qquad (1)$$

Where:

M_c = Moisture content on wet basis (%)

W_i= Initial weight of the sample (g)

W_f= Final weight of the sample (g).

2.6.2. Grain straw ratio

Grain-straw ratio was determined following procedures. From the finger millet grain which was to be threshed, 3 samples were randomly taken of approximately, 0.5kg. The samples were placed in containers where the grains and straw were separated by hand. The straw and grains from each sample were kept paired. After weighing, the samples were oven dried at 130°C for at least 15 hours and then reweighed (Huehn 1993) .After determining the weight of dry samples the results of the paired samples were used to calculate the mean Grain/Straw-ratio. The Grain-Straw ratio (K) was calculated as follows: Patel and Naik (2022).

$$k = \frac{\text{weight of dry grain}}{\text{weight of dry straw}} \qquad (2)$$

2.6.3. Threshing capacity

The thresher capacity of the machine was determined using the relationship as determined by Ndirika, (1994) and Akintayo, (2015).

$$T_c = \frac{Q_s}{t} \qquad (3)$$

Where:

T_c = Threshing capacity expressed in kilogram per minute (kg /h)

Q_s = quantity of grains collected at the grain outlet in kilogram

t = time taken to thresh in minutes.

2.6.4. Threshing efficiency

The threshing efficiency of the machine was determined using the relationship as determined by Ndirika, (1994) and Akintayo, (2015).

$$T_E = 100 - \frac{Q_u}{Q_t} \times 100 \qquad (4)$$

Where:

T_E= threshing efficiency in percentage

Q_u =unthreshed quantity of grains in a sample in kg

Q_t = the total quantity of grains (kg) threshed and unthreshed in the Sample.

2.6.5. Cleaning efficiency

The cleaning efficiency was determined using the relationship determined by Ndirika, (1994) and Akintayo, (2015).

$$C_E = \frac{(W_t - W_c)}{W_t} \times 100 \qquad (5)$$

Where:

C_e = Cleaning efficiency in percent

W_t = total weight at the outlet in kilogram

W_c = chaff weight at the outlet in kilogram.

2.6.6. Threshing loss

Scatter loss was determined using the relationship by Ndirika, (1994) and Akintayo, (2015)

$$S_L = \frac{Q_l}{Q_t} \times 100 \qquad (6)$$

Where:

S_L= Scatter loss expressed as a percentage

Q_l =the quantity of grains scattered from the machine in kilogram

Qt =total quantity of sample grains in Kilogram.

2.6.7 Fuel consumption

Fuel consumption of the machine was determined by fill methods, before the start of each test trial, the fuel tank ware filled to its capacity and after each test trial; the fuel consumed measured by refilling the tank to the same level using a graduated cylinder. Mathematically can be calculated by this equation.

$$F_c = \frac{Q}{t} \qquad (7)$$

2.7. Experimental Design

The performance tests of the developed finger millet threshing thresher was conducted at three different levels of cylinder speed (600.00, 700.00, 800.00 rmp) and three levels of feeding rates (6.00, 9.00, 12.00 kg/min) using factorial arrangement of 3 x 3 x 3 in a CRD with three replications of each treatment. Comparison between treatment means was done by least significant difference (LSD) at 5.00% level.

2.8. Data Analysis

The data was analyzed by using R-statistic software and treatment means that are different at a 5% level of significance was separated using LSD.

3. Results and Discussions

3.1. Effect of feed rate on threshing capacity

The mean values of threshing capacity increased from 185.73 to 239.63 and then to 279.18 kg/hr as feed rate increased from 6 to 9 and to 12 kg/min, respectively (Table 1). The effect of feed rate on the threshing capacity of the machine revealed that threshing capacity was significantly influenced by varying feed amounts. These findings are supported by the report of Amponsah et al. (2017) which showed threshing capacity increment as feed rate increased.

Table 1 also illustrates the effect of feed rate on the threshing efficiency of the machine. The mean percentage values of threshing efficiency decreased from 97.31 to 96.72 and then down to 96.20% as feed rate increased from 6 to 9 and then to 12 kg/min. This finding aligns with the work of Kumar et al., (2022) who observed a similar relationship between feed rate and threshing efficiency. The mean values of the cleaning efficiency were 96.53, 96.45 and 95.95%, respectively, at feed rates of 6, 9 and 12 kg/min. This finding aligns with results reported by Ashebir et al. (2023) for a teff threshing machine. Similarly, the threshing loss, of mean values of 1.82, 1.91 and 2.26% were obtained at feed rates of 6, 9 and 12 kg/min, respectively, however, the feed rate changes did not significantly effect on threshing loss.

An analysis of the relationship between feed rate and machine fuel consumption (Table 1) using LSD to compare means revealed statistically significant differences among all feed rates. Increasing in feed rate from 6 to 9 and then to 12 kg/min led to increase in fuel consumption from 42.68 to 49.47 and then to 59.38 ml/kg, respectively. Similar trends have been reported by Ahmad et al. (2013) the feed rate have highly significant effect on fuel consumption of machines.

Table 1. Main effects of feed rate on various performance metrics of the finger millet threshing machine, including threshing capacity, threshing efficiency, cleaning efficiency, threshing loss, and fuel consumption.

Feed rate (kg/min)	TC(Kg/hr)	TE (%)	CE (%)	TL (%)	FC (ml/min)
6	185.73 ± 18.38[c]	97.31 ±1.27[a]	96.53±1.4 [a]	1.82 ± 0.53[a]	42.68[c] ± 0.62
9	239.63 ± 26.68 [b]	96.72 ±1.14[b]	96.45±0.36[a]	1.91 ± 0.60[a]	49.47[b] ± 0.75
12	279.18 ± 32.92[a]	96.20 ±1.09[c]	95.95±1.01[a]	2.26 ± 0.65[a]	59.38[a] ± 0.29
LSD	3.74	0.07	0.70	0.44	1.61
CV	2.81	0.37	1.22	0.09	2.10

3.2. Effects of drum speed on performance of finger millet threshing machine

The effects of threshing drum speed on the threshing capacity, threshing efficiency, cleaning efficiency, threshing loss and fuel consumption of the finger millet threshing machine are presented in Table 2. The threshing capacity increased from 209.24 to 233.54 and 261.35 kg/hr as drum speed increased from 600 to 700 and to 800 rpm, respectively. The comparison of means using LSD indicated that, at all speeds, the threshing capacity showed highly significant differences. The results of this study align with the findings reported by The results of this study align with the findings reported by Abdeen et al., (2025)and Olaye et al. (2016) regarding the impact of drum speed on the threshing capacity of paddy threshing.

Similarly, threshing efficiency revealed significant variations with changes in drum speed across all tested speeds. The values were 95.55, 96.81 and 97.87% at speed of 600, 700 and 800 rpm, respectively. This result further supports the idea that variations in drum speed have a significant influence on threshing efficiency, in line with previous research by Singh et al. (2018) which reported threshing efficiency values of 89.00, 91.10, and 96.55% at speeds of 625, 750, and 875 rpm, respectively, with statistically significant differences (P<0.05) between them. Amponsah et al. (2017) also found similar result that threshing efficiency increased from 93.8 to 96.5% with increase of drum speed 550 to 650 rpm**.**

Table 2. Also presents that the effect of drum speed on the cleaning efficiency is significant. Maximum and minimum values were 97.36 and 95.67%, at 800 and 600 rpm, respectively This finding make straight well with results reported by Tsegaye.et al (2023) ,), which observed an increase in cleaning efficiency from 95.86% at 800 rpm to 97.56% at 1000 rpm and further to 98.57% at 1200 rpm. The effects of drum speed on the threshing loss of the machine, as presented in Table 5, are significant. They increased from 1.42% at 600 rpm to 2.59% at 800 rpm. Table 2 also illustrates the effect of speed on the fuel consumption of the machine. The mean values increased from 47.98 to 49.47 and then down to 59.38 ml/min as drum speed increased from 600 to 700 and then to 800 rpm. Fuel consumption was significantly affected by drum speed. (Olaye et al. 2016) showed similar result as drum speed increased the fuel consumption increased.

Table 2. Main effects of drum speed on performance metrics of the finger millet threshing machine, including threshing capacity, threshing efficiency, cleaning efficiency, threshing loss, and fuel consumption,

Speed (RPM)	TC (Kg/h)	TE (%)	CE (%)	TL (%)	FC(ml/min)
600	209.24± 38.40[c]	95.55 ± 0.47[c]	95.67± 0.59[b]	1.42 ± 0.14 [c]	47.98[c] ± 0.64
700	233.54 ± 48.48[b]	96.81 ± 0.60 [b]	95.88 ± 0.30[ab]	1.99 ± 0.39 [b]	49.47[b] ± 0.23
800	261.35 ± 53.29[a]	97.87 ± 0.67[a]	97.36 ± 0.67[a]	2.59 ± 0.17[a]	59.38[a] ±0.60
LSD	3.74	0.07	0.70	0.44	1.61
CV	2.81	0.37	1.22	0.09	2.10

3.3. Interaction effect of feed rate and drum speed on performance of finger millet threshing machine

3.3.1. Interaction effects of the drum speed and feed rate on threshing capacity

The interactions result of drum speed and feed rate on the threshing capacity are presented in Table 3. Comparison between means using LSD indicated that at all feed rates and speeds, the threshing capacity values were significantly different. The maximum threshing capacity, 311.9kg/hr, was recorded at 12 kg/min feeding rate combined with an 800-rpm drum operating speed and the minimum threshing capacity of 169.55 kg/hr was recorded at combination of 6 kg/min feed rate and 600 rpm drum speed. The findings align with those of Vejasit and Salokhe(2006),who noted an increase in the threshing capacity of a paddy thresher both drum speed and feed rate . Similarly, Faisal and Nasr (2020) Observed a similar trend, where the machine's capacity increased with higher feed rates and drum speeds.

3.3.2. Interaction effects of the drum speed and feed rate on threshing efficiency of the machine

The results presented in Table 6 demonstrate the significance of the interaction between feed rate and speed in maximizing the threshing efficiency of the finger millet threshing Machine. As indicated in Table 3, the maximum threshing efficiency that was measured was 98.63% when the drum speed was running at 800 rpm and the feed rate was 6 kg/min. The trends show that when feeding rate increased, threshing efficiency consistently decreased at all drum speeds. However, threshing efficiency increased as drum speed increased. These results are consistent with those of Mansour and Aboegela (2023), who found that increasing drum speed from 600 to 750 rpm raised threshing efficiency from 96.6% to 99% at feed rates of 720 and 360 kg/h, respectively. Similarly, Faisal and Nasr (2020) observed that increasing the feeding rate from 10 to 20 kg/min decreased threshing efficiency from 93 to 87%, but as drum speeds increased from 1400 to 1600 rpm, threshing efficiency increased from 93 to 95%.

3.3.3. Interaction effects of the drum speed and feed rate on cleaning efficiency of the machine

Table (3) shows that the interaction effect of drum speed and feed rate had not significant effect on cleaning efficiency. This finding aligns with the results reported by Ashebir et al., (2023).

According to their result, cleaning efficiency has a direct relationship with drum speed an increase in drum speed corresponds to an increase in cleaning efficiency, while an increase in feed rate leads to a decrease in cleaning efficiency. The highest cleaning efficiency of 98.13% was observed at a feed rate of 6 kg/min and an 800 rpm drum speed. Conversely, the lowest cleaning efficiency of 95.34% occurred at 6 kg/min with a 600 rpm drum speed, as illustrated in table 3.

This pattern is consistent with the findings of Mansour and Aboegela (2023),who reported similar trends in cleaning efficiency related to drum speed and feed rate. In their study, increasing the peripheral drum speed from 600 to 750 rpm corresponded to an increase in cleaning efficiency from 96.7 to 98.8%. However, increasing the feed rate from 360 to 720 kg/hr resulted in a decrease in cleaning efficiency from 98.8 to 97.5%.

3.3.4. Interaction effects of the drum speed and feed rate on threshing loss of the machine

The analysis conducted on threshing loss concerning the interaction of feed rate and speed provides valuable insights into the performance of the threshing machine under varying operational conditions. The LSD All-Pairwise Comparisons Test results revealed three homogeneous groups (A, B, and C), indicating the absence of significant differences among means within each group, this result the same with reported (Ashebir et al., 2023).

The analysis indicates a direct relationship between threshing loss and drum speed, showing that as the drum speed increases, the threshing loss percentage also increases. The threshing loss observed was 2.75% at a feed rate of 12 kg/min with a drum operating speed of 800 rpm, while the threshing loss was recorded at 1.330% for a feed rate of 6 kg/min with a drum speed of 600 rpm. This finding make straight well with results reported by Sudajan and Salokhe (2015).

3.3.5. Interaction effects of the drum speed and feed rate on fuel consumption

Table (3) shows that the interaction effect of drum speed and feed rate have significantly affected fuel consumption. As for the effect of the interactions between drum speed and feeding rates on fuel consumption (Table 3) the results indicated that under all feeding rates the increase of drum speed resulted in a high increase in fuel consumption. The maximum fuel consumption of 63.06 ml/min was observed at a feed rate of 12 kg/min and an 800 rpm drum speed.

On the other hand, the minimum fuel consumption of 39.36 ml/min occurred at 6 kg/min with a 600-rpm drum speed, as shown in Table 6. The results were in agreement with Amponsah et al. (2017).

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Table 3. Interaction effects of feed rate and drum speed on the performance metrics of the finger millet threshing machine, focusing on threshing capacity, threshing efficiency, cleaning efficiency, threshing loss, fuel consumption

Speed (rpm)	Feed rate (kg/min)	TC (kg/hr)	TE (%)	CE (%)	TL (%)	FC (ml/min)
	6	169.55 ± 2.91[i]	96.07 ± 0.84[c]	95.53 ±1.45[b]	1.33 ± 0.70[c]	39.36 ± 0.63[h]
600	9	213.05 ± 2.60[f]	95.44 ± 0.20[cd]	96.33 ± 1.21[ab]	1.36 ± 0.38[c]	47.79 ±1.08[ef]
	12	246.32 ± 3.28[d]	95.14 ± 0.51[d]	95.17 ± 2.42[ab]	1.58 ± 0.74[c]	56.03 ±1.16[c]
	6	181.92 ± 2.65[h]	97.24 ± 0.29[b]	95.92 ± 0.85[ab]	1.72 ± 0.62[bc]	42.47 ±1.02[g]
700	9	239.43 ± 2.22[e]	97.07 ± 0.3[b]	96.17 ±1.20[ab]	2.44± 0.44[ab]	49.45 ±1.30[e]
	12	279.29 ± 4.65[b]	96.12 ± 0.16[c]	95.56 ± 1.60[ab]	1.81± 0.34[bc]	59.05±2.44[b]
	6	205.72 ± 2.40[g]	98.63 ± 0.09[a]	98.13 ± 1.24[a]	2.40 ± 0.28[ab]	46.21 ±1.66[f]
800	9	266.40 ± 3.54[c]	97.65 ± 0.07[b]	96.86 ± 1.65[ab]	2.62 ± 0.26[a]	52.66 ± 1.67[d]
	12	311.95 ± 2.69[a]	97.33 ± 0.22[b]	97.09 ± 0.92[ab]	2.75 ± 0.20[a]	63.06 ±1.32[a]
LSD		4.87	0.68	2.12	0.76	2.78
CV		1.21	2.12	2.75	1.72	1.32

Where, TC = Threshing capacity, TE = Threshing efficiency, CE = Cleaning efficiency, TL = Threshing loss, FC = Fuel Consumption, LSD = Least significance difference, CV = Coefficient of variation.

4. Conclusions and Recommendations

The effects of feed rate and cylinder speed on threshing capacity, threshing efficiency, cleaning efficiency, grain loss, and fuel consumption were computed during the performance evaluation. The following conclusions were drawn from the results obtained.

- The main effect of feed rate and cylinder speed affected threshing capacity, threshing efficiency, and fuel consumption, while cylinder speed only affected cleaning efficiency and threshing loss.
- The feed rate and cylinder speed interactions have significant effects on threshing capacity, threshing efficiency, and fuel consumption, but not on cleaning efficiency and threshing loss.
- The threshing capacity, threshing loss, and fuel consumption increased with cylinder speed and feed rate levels increased.
- The threshing efficiency and cleaning efficiency increased with increasing cylinder speed and decreased with increasing feed rate.
- Generally, the performance of the developed finger millet thresher was found to be acceptable based on the results obtained, which suggested that the threshed could effectively replace the tedious, laborious and wasteful traditional methods of threshing finger millet.

5. Future Suggestions

- The thresher was found to be difficult to transport manually due to a lack of mobility options. It is recommended to provide wheels so that it can be easily pulled by animals or a single-axle tractor.
- It is advisable to reevaluate the thresher at various feed rates and cylinder speeds using different varieties of finger millet crops to further optimize its performance.

○ Incorporating adjustable components for cylinder speed and feed rate could enhance the thresher's versatility, allowing users to fine-tune settings based on specific crop conditions and desired outcomes.

○ Conducting field trials in diverse environmental conditions will help assess the thresher's durability and performance under varying moisture levels and crop densities, ensuring it meets the needs of different farming practices.

Declarations

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Competing Interests Statement

The authors have declared that no competing financial, professional, or personal interests exist.

Consent for publication

Both the authors contributed to the manuscript and consented to the publication of this research work.

Availability of data and material

Supplementary information is available from the authors upon reasonable request.

Authors' contributions

Both the authors took part in literature review, analysis, and manuscript writing equally.

Institutional Review Board Statement

Not applicable for this study.

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