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Modeling of Thresher Capacity and Fuel Consumption Equations Using Dimensional's Analysis for Threshing Operation

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ABSTRACT

Threshing capacity and fuel consumption in postharvest operations are the main factors in selecting a thresher. The problem was user was not easily understood the relation thresher capacity and fuel consumption. To easily understand the relationship, a model is needed for the independent and dependent factors. The model was developed for threshing capacity, and fuel consumption depends on parameter factors. The purpose of modeling is to select threshers, estimate thresher capacity, and identify direct and indirect factors. There are nine independent variables. These are: cylinder diameter (d), cylinder length (L), concave clearance (Cc), feed rate (Fr), drum speed (S), moisture content (Mc), crop straw ratio (R), spike/peg length (PL), and crop bulk density (ρ) and The Buckingham, pi theorem is used in basic dimensional. The threshing capacity and fuel consumption were developed. The equation was TC is equal to $d^2 v\rho\ (L{*}d^{-1},\ L{*}d^{-1},\ Fr\ {*}d^{-2}V\rho)\ MC{*}\ SR$ *and for fuel consumption of stationary thresher was Fc is equal to* $d^2 v\ (L{*}d^{-1},\ L{*}d^{-1},\ Fr{*}d^{-2}V\rho)\ MC{*}\ SR$ *developed. The performance investigation was conducted at three levels of drum speed (1000, 1100, and 1200 rpm) and feed rate (600, 700, and 800 kg* h^{-1}*) with split-plot experimental design. The maximum threshing capacity is 234.22 kg* h^{-1} *at feed rate 800 kg* h^{-1} *and a drum speed of 1200 rpm and it consume 2.245 L* h^{-1}*. The lowest threshing capacity is 223.20 kg* h^{-1} *at drum speed is 1000 rpm and the feed rate is 600 kg* h^{-1} *with fuel consumption is 2.00 L* h^{-1}*. The equation developed contributed to research in that it helped researchers and designers easily understand the relation of thresher performance determinants. Consequently, using a model created by dimensional analysis is the most effective method for comprehending thresher-related parameters as result, as the speed of the drum increases, the thresher capacity increases as fuel consumption increases. Therefore, the developed model is a simple and easy way to choose and design the thresher.*

Keywords: *Thresher capacity, Fuel consumption, Dimensional analysis, Buckingham Pi theorem*

INTRODUCTION

Agriculture mechanization can determine the development of a country. Especially, the economy is based on agriculture. It has had significant changes in the growth of domestic products. The effect of mechanization on agricultural implementation leads to sustainable development when using agricultural machinery. According to the suggestions of numerous nations around the world, agricultural mechanization has had a significant effect on the world economy (Kaumbutho and Takeshima, 2020). The machinery supported crop production agriculture is result economic growth (Indexed *et al.*, 2017).

The profitability of farming as well as the availability of the farm machines have significantly impacted on the level of mechanization (Kaumbutho and Takeshima, 2020). The current status of mechanized farming and machinery adoption in developing countries is the main the mains issue especially in Ethiopia. The farming system makes easy way for production and increases the productivity by timelines operation and drudgery reduction. Using machinery makes to easy operate, saves energy, time, and reduces loss is preferred (Tsegaye *et al.*, 2020). The machinery applications used during the crop production for plowing, planting, harvesting, threshing, storing, and transportation under pre-harvest and post-harvest operations (Deribe *et al.*, 2022). The main objectives of mechanization technologies for pre-harvest operation and post-harvest production are to increase working quality, efficiently use energy, decrease post-harvest loss, save time, minimize drudgery, improve output quality, and conserve energy. In the mechanical post-harvest operation, multi-crop threshers are used to thresh wheat, barley, and sorghum on a small, medium, and large scale. The threshing operation is performed by a combination of impacting and rubbing to detach the kernels from the ears (Kumar, 2017).

The threshing performance determinants are design factor, crop factor and operational are the main parameter. Both axial threshing and tangential type threshing technologies are widely used in grain threshing systems (Deribe *et al.*, 2021). The Stationery thresher for developing country is used to reduce the amount of energy required for crop threshing and minimize drudgery during threshing operations (Shekhar, 2020). Threshing performance and thresher cost are determined during threshing based on threshing capacity and fuel usage.

Therefore, the primary outcome for design operation is fuel consumption in order to maximize the end-threshing capacity, optimize process design, and estimate cost (Abich, 2018). Threshing capacity and fuel consumption are the key factors that influence thresher performance and selection. Three factors were taken into consideration when designing the thresher: the crop factor, the design factor, and the human aspect, or feeding factor (Abich, 2018). The total grain losses, the stationary thresher's threshing and cleaning efficiency, and their combined effects should all be taken into account during the design of the thresher (Shreen *et al.*, 2016).

According to Belay and Fetene (2021); Afolabi *et al.* (2017), The thresher performance evaluation was significantly changed by crop moisture content. Additionally, the performance of grain damage is influenced by the pattern of contact between grain crops and threshing components. The grain damage decreased along with high crop moisture content, while threshing performance decreased. Power usage increased along with the amount of energy used to thresh the crop at higher moisture content. Increasing the drum's diameter, number of beaters, peg beaters, and length all increase the threshing capacity (Afolabi *et al.*, 2017). The operating time and the amount of grain output for thresher capacity of influenced by its shape and size drum. Threshing efficiency is affected by the number of rows of artificial teeth fixed to the drum, the type of crop, the feeding speed of the threshing chamber, the angle of the thresher concave, and the speed of the drum (Indexed *et al.*, 2017). The thresher performance depends on the cylinder diameter, concave clearance, concave length, and threshing speed, which are direct relationships. The feed rate influences the seed passing through the concave clearance (Thet *et al.*, 2019). Also the feed rate had a direct relationship with threshing capacity (Awgichew, 2019). According to Ahorbo (2016), suggestion the fed rate impact of thresher operation on in terms of energy consumption and threshing capacity which have direct proportional.

According to Journal and Dula (2019), As cylinder speed increases, threshing capacity increases. Increased impact energy from faster speeds increases thresher capacity and increases fuel consumption. Additionally, it relates to the crop variety, human factors, and design factors that affect the thresher performance (Al-shamiry *et al.*, 2020).

During thresher design, understanding the relation between the thresher factor and design, the testing selection model can be used in a simple way. That models will be needed for thresher selections and designs. The dimensional application is the most effective for modeling and estimation of threshers' parameters identification technique. The goals are to identifications the most effective parameters to minimize the total number of variables and non-dimensional groups of variables. When Dimensional's apply the dependent and independent factor to carefully identify and filtering the important parameters as it is advisable recommended methods. the parameter variables in the groups were frequently organized so that each group had physical relevance (Garcia-Suarez et al., 2019). The basic dimensional and theorem of Buckingham's were used to generate equations based on the parameter factor. They are different suggestions for studded throughput per unit energy usage and thresher performance. Since the principles of construction and thresher operation are not well defined (Abich, 2018). The three most significant aspects that impact the thresher's performance are crop variety, feed rate, and cylinder speed (Ajmal *et al.*, 2017).

The main problem during thresher design was identification parameter relationships. Some are direct relationships, and some are indirect relationships. During the performance evaluation, parameters were also considered, but the relationship was not clearly defined. Due to that, there is different confusion for the design, selection, and evaluation of the thresher. Understand the fundamental design elements that one should anticipate from agricultural engineers or designers in order to design, test, and select the thresher. In order to comprehend thresher performance selection and design equipment parameters, it is necessary to study the thresher factor for determining thresher capacity and optimization by fuel consumption.

So, it is necessary to develop simple model calculations for researchers, designers, and others for easy understanding. To be used to construct and optimize thresher design for threshing capacity and fuel consumption during operation. The aim of this study was the determination of the equation or model for thresher threshing capacity and performance evaluation for simple understanding and estimation. Then, finally, a performance evaluation based on a parameter factor for comparing the practical result with the developed equation. The main purpose was model development for the thresher capacity and fuel consumption equations using dimensional data. Finally, the purpose is to evaluate thresher performance to compare with the developed model.

MATERIALS and METHODS

Description of the studies area

The tests were conducted in the Oromia region, East of Shewa, Awash Melkasa at Wake Tiyo Kebeles. During the performance tests the thresher was obtained from the Melkassa Agricultural Research Center's and Department of agricultural Engineering research.

Techniques of Using Dimensional Analysis to Develop Models for Thresher Capacity and Fuel Consumption Equation

A fuel consumption equation was developed using the theorem of Buckingham based on the basic dimensions of parameters. The thresher capacity based on the thresher parameter factor. In dimension analysis, there are two method of techniques to solve the variables approach to generate modeling (Program and Plantation, 2022): (Singla *et al.*, 2022). The Rayleigh and Buckingham pi theorems, which incorporate combinations of mass, length, and time or force, are examples of these methods. Rayleigh's approach is not often used because of its complexity when handling large numbers of variables. In addition, our study makes use of the Buckingham pi theorem. Using the fundamental dimensions are: length, Time and mass applied for the theorem of the Buckingham pi for gradually used to generate the final associated equation.

The step used was one. Enumerate the independent parameters factor or thresher capacity and fuel consumption. There are nine overall quantities (n) for both fuel consumption and thresher capacity. The parameters are cylinder radius (d), length of the cylinder (L), concave clearance (Cc), feed rate (Fr), drum speed (S), moisture content (Mc), crop straw ratio (R), spike/peg length PL, and crop bulk density (ρ). The thresher capacity (TC) and fuel consumption (Fc) are the dependent factors (Pandey and Stevens, 2016). Next were listed the principal dimensions of all nine factors.

Table 1 represents the dependent and independent factors of thresher performance evaluation, and the basic units listed below for nine based on impact and relation identification are listed below. To model, consider the three basic fundamentals: length with its units, mass with its units, and time with its units, as shown below. Analyzed and noted in similar tendencies are (Nkakini *et al.*, 2019; Program and Plantation, 2022).

Table 1. *The parameter of thresher for performance equation determination.*

Variables	Symbols'	Dimension symbols	Units
In depend parameters			
Bulk density	D	$L^{-3}M$	kg m^{-3}
Drum radius	R	L	m
Drum length	Dl	L	
Concave clearance	Cc	L	m
Peg length	L	L	m
Feed rate	Fr	$M\,T^{-1}$	kg s^{-1}
Moisture content	Mc	-	
Straw ratio	SR	-	-
Drum speed	V	$L\,T^{-1}$	$m^3\,s^{-1}$
Dependent parameters			
Fuel	F	$L\,T^{-3}$	$m^3\,s^{-1}$
Thresher capacity	TC	$M\,T^{-1}$	kg s^{-1}

Then, using the determinant and constants parameters, the next procedure was determining the number of primary dimensions (M) based on the reduction. The expected number of IIs, by calculating k, which is the number independent factor minus the number determinant factor, which is nine minus three, equal to six. Where N represents the total amount of performance evaluation parameter factor and M, represents the basic number of fundamental dimensions: time (T), mass (M), and Length (L), then there are six IIs needed to be modelling the equation for thresher capacity and fuel consumption.

The fourth step was to select the repeating parameters (j), and several guidelines have been proposed to select the repeated variables (Jarolmasjed *et al.*, 2013; Singla *et al.*, 2022), Choose the parameters that repeat (j). A number of recommendations have been made to choose the recurring variables. To ensure that only one pi carries the dimensional value, whenever possible, choose dimensional constants over dimensional variables. Select common parameters as they might show up in all of the IIs. Whenever feasible, choose simple variables over complex ones. Drum radius (R), drum speeds (V), and densities (D) are chosen as repeated parameters based on the aforementioned eight guidelines, and the same pattern is shown in Jarolmasjed *et al.* (2013); Program and Plantation (2022).

The final steps was construct the "k" IIs and adjust as needed. The following manipulation and construction are applied to the six identified pi terms:

$$TC = f\,(R, L, Cc, Fr, Mc\ SR, V, D) \tag{1}$$

$$F = f\,(R, L, Cc, Fr, Mc\ SR, V, D) \tag{2}$$

$$\pi_1 = (\pi_2, \pi_3, \pi_4, \pi_5, \pi_{6,}) \tag{3}$$

The determination of $\pi 1$ is the function of thresher capacity and fuel consumption, drum radius (R), drum speed (v), and crop densities (D). Based on the theorem, it was developed by considering dimensional analysis. $\pi_1 = (TC, r, V, D)$ and $\pi 1 = (F, r, V, D)$ for both threshing capacity and fuel consumption. π_2 is the function of drum radius (R), drum length (L), and bulk density (D). In function form, $\pi_2 = (L, R, V, D)$. For equation development, $\pi 3$ is the function of concave clearance (Cc), drum radius (R), drum speed (V), and crop densities (D). The function was $\pi_3 = (Cc, R, V, D)$. For $\pi 4$ equation development, it is the function of drum radius (R), feed rate (Fr), and bulk density (D), where π_4 = (Fr, R, V, D). Then for the $\pi 5$ equation, it is the function of drum radius (R), moisture content (Mc), speed (V), and bulk density (D), and the function form was π_5 = (Mc, R, V, D). Finally, $\pi 6$ is the function of drum radius (R), straw ratio (SR), drum speed (V), and crop density (D), and the equation was π_6 = (SR, R, V, D) was the Pi function threshing capacity and fuel consumption.

For manipulation of $\pi 1$ and the formulation π_1, is equal to TC. R^a. V^b. D^c & $M^0L^0T^0$ = MT^{-1}. $(L)^a$. $(LT^{-1})^b$. $(ML^{-3})^c$ and when we apply basic dimensions for M, = 0, c = -1 and For L, 0=a+b-3c solve for T and insert b value in this equation gives; a = -2, and For T, = 0 = -1-b; b=-1, finally, $\pi_1 = \mathrm{T}Cd^{-2}V^{-1}\rho^{-1}$.

The manipulation of $\pi 1$ for threshing capacity and the formulation $\pi 1$ are equal to TC* V^a* R^b* D^c and $L^0T^0M^0$. Then, by considering dimensions, application equals $MT^{-1}(LT^{-1})^a(L)^b(ML^{-3})^c$. and then $L^0T^0M^0 = MT^{-1}(LT^{-1})^a(L)^b(ML\text{-}3)^c$ by using the theorem of Buckingham for determination relation as shown below. From the above relation and solving for the values when L = 0, then the exponent relation a + b = 3c. The value of T = 0, then the value of an exponent based on the theorem is a = -1. Finally, when the value of M = 0, then C = -1, then y substitution, the value of b = -2. The value of C is -1, then when T is a zero exponent, the value of b is -1, and when we substitute the values in equation $\pi 1$ are equal to TC $(V)^{-1}$. $(R)^{-2.}$ $(D)^{-1}$

$$\pi_1 = \frac{TC}{R^2VD} \quad \text{dimensionless (for threshing capacity)} \tag{4}$$

For determination of thresher performance with fuel utilization of π_1 modeling formulation shown below and the formulation π_1 = F. (V^a. R^b. D^c) and $L^0M^0T^0 = L^3T^{-1}(LT^{-1})^a * (L)^b * (ML^{-3})^c$ based on theorem application and the developed equation when L = 0 then 3 + a + b –c and for solved m, is the values c = 0 for T, is =0 For M, = 0, a = -1 and solve for T is zero and insert b value in this equation gives; b = -2. When we substitute

$$\pi_1 = FR^{-2}V^{-1} = \frac{F}{R^2V} \quad \text{dimensionless (for fuel consumption)} \tag{5}$$

For determination of thresher performance with fuel utilization of π_2 modeling formulation shown below and the formulation π_{12} = L. (R^a. V^b. D^c) and $L^0M^0T^0$ = L $(L)^a * (LT^{-1})^b * (L^{-3}M)^c$ based on theorem application and the developed equation when is, M zero, C is zero. Then L, = 0 the apply theorem -1 = a + b - 3c. Then when solving for T, side zero the value of result b is zero. Then L is zero, 0=1+a+b-3c solve for T and insert b value in this equation gives; a= -1 then substitute in to below equation.

$$\pi_2 = LR^{-1}V^0D^0,\ \pi_2 = \frac{L}{R} \quad \text{dimensionless} \tag{6}$$

The equation $\pi 3$ and its value of $\pi 3$ = Cc. R^a. V^b. D^c were used to develop the equation $\pi 2$ of $\pi 2$ = L. Ra. Vb. Dc, and $T^0L^0M^0$ = L $(L)^a * (LT^{-1})^b * (L^{-3}M)^c$ then the value of M, zero c is also zero. Then L, is 0=1+a+b-3 c, solve for T is zero b is zero and insert b, which is zero and equals then the value of a is -1. Then equation was shown below.

$$\pi_3 = LR^{-1}V^0D^0 \quad \pi_3 = \frac{L}{R} \quad \text{dimensionless.} \tag{7}$$

To represent the equation of $\pi 4$s, which is equivalent to = Fr. R^a. V^b. D^c & $T^0 M^0 L^0 = MT^{-1} (L)^a (T^{-1}L)^b (L^{-3}M)^c$ and use simple dimensions. For M, 0=1+c; c=-1, then for L, 0=+a+b+3 Solving for T and inserting b into this equation yields: a=2. For T: 0 = -b, b = -1, and lastly, $\pi 4$. =Fr $R^{-2} V^{-1} D^{-1}$

$$\pi_4 = \frac{\mathrm{Fr}}{\mathrm{R^2VD}} \text{ dimensionless} \tag{8}$$

Manipulating $\pi 5$ and equal Mc. R^a. V^b. D^c. Then use dimensional analysis. $M^0 L^0 T^0 = (L)^a (LT^{-1})^b (L^{-3}M)^c$ Apply basic dimensions. For M, 0 = +c and c = 0. For L, 0=1+a+b-3c solve for T and put the b value in this equation provides; a=0 and for T, 0 = -b; b=0 and finally, $\pi_5 = \mathrm{Mc}\ V^0 \rho^0 d^0 = \mathrm{Mc}$; dimensionless.

Modeling for $\pi 5$ and $\pi 6$ = SR. R^a. V^b. D^c (9)

$T^0 M^0 L^0 = (L)^a (L) T^{-1}L)^b (L^{-3}M)^c$ then apply the basic dimensions. For M, 0 equals +c and c equal 0. For L, 0=1+a+b-3c, solve for T and enter b value in this equation provides; a=0 and for T, 0 = -b; b=0 and lastly, $\pi_5 = \mathrm{SR}\ d^0 \rho^0 V^0 = \mathrm{SR}$, dimensionless. The necessary π groups are successfully identified, verified, and dimensionless.

Step 6: Check your math and write the final functional connection. We can represent fuel consumption as follows as it depends on other factors, as shown in equations 1 and 2. $\pi 1 = (\pi 2, \pi 3, \pi 4, \pi 5, \pi 6)$ was the formula that was created for the threshing capacity and fuel consumption of the thresher. $\frac{\mathrm{TC}}{\mathrm{R^2VD}} = (\frac{\mathrm{L}}{\mathrm{R}}, \frac{\mathrm{L}}{\mathrm{R}}, \frac{\mathrm{Fr}}{\mathrm{R^2VD}},)\ \mathrm{MC}^*\ S\mathrm{R}$ and this is the developed thresher capacity, which is directly proportional to the drum's radius, speed, length, feed rate, straw ratio and moisture content. The final equation developed for threshing capacity is shown below in Equation (10).

$$\mathrm{TC} = \mathrm{R^2vD}\ (\frac{\mathrm{L}}{\mathrm{R}}, \frac{\mathrm{L}}{\mathrm{R}}, \frac{\mathrm{Fr}}{\mathrm{R^2V\,D}},)\ \mathrm{MC}^*\ S\mathrm{R} \tag{10}$$

For fuel conception, $\frac{\mathrm{F}}{\mathrm{R^2v}}$ = (= $(\frac{\mathrm{L}}{\mathrm{d}}, \frac{\mathrm{L}}{\mathrm{d}} \frac{\mathrm{Fr}}{\mathrm{d^2V\rho}})\ \mathrm{MC}^*\ S\mathrm{R}$). The model created fuel consumption model for stationary threshers were $\mathrm{F} = \mathrm{R^2v}\ (\frac{\mathrm{L}}{\mathrm{R}}, \frac{\mathrm{L}}{\mathrm{R}}, \frac{\mathrm{Fr}}{\mathrm{R^2VD}},)\ \mathrm{MC}^*\ S\mathrm{R}$ .The testing was conducted to check the relation of model for threshing capacity and fuel consumption of the multi-crop thresher's performance was tested and evaluated. For fuel conception equation the developed equation shown below based on dimension analysis in Equation (11).

$$\mathrm{Fc} = \mathrm{d^2v}\ (\frac{\mathrm{L}}{\mathrm{d}}, \frac{\mathrm{L}}{\mathrm{d}}, \frac{\mathrm{Fr}}{\mathrm{d^2V\rho}},)\ \mathrm{MC}^*\ S\mathrm{R} \tag{11}$$

When the performance was conducted at Wake Tiyo Awash Melkasa, East Oromia zone, the agronomic data were recorded, such as crop length and speck length, during the thresher testing. The performance investigation was conducted at three levels of drum speed (1000, 1100, and 1200 rpm) and feed rate (600, 700, and 800 kg h^{-1}). Testing parameters and data collected were drum speed, feed rate, concave clearance, fuel consumption, and biomass weight before threshing, and moisture content. Asplit-plot experimental design was used to investigate thresher capacity, with drum speed as the primary factor and feed rate as a sub factor.

Statistical data analysis

Data were collected based on agronomics' for testing and engineering parameters are recorded. Statistics 8 was used to do the analysis. The thresher's data's studies were concentrated on thresher performance and fuel usage, and analysis of variance (ANOVA) was performed to compare treatments. To distinguish statistically significant differences between treatment means at the 5 percent significance level, the least significant difference (LSD) was used (5 percent). To establish the association's significance, an analysis of variance and an F-tests were utilized.

RESULTS AND DISCUSSION

The thresher's performance was tested conducted based on different parameters. After the result was analyzed, the effect of the thresher parameter on thresher capacity and fuel consumption was evaluated. The impact of threshing speed, cleaning efficiency, efficiency, capacity, and percentage of loss achieved. A thresher tested at 12 percent moisture on the Tef Komcho variety. Tef is harvested when the seeds have dried and reached physiological maturity. Throughout testing, information on crop and equipment performance was successively recorded. The data on the crop was recorded both before and after threshing, including plant height, speck height, chaff length, optimal tef moisture content, variety of tef grain, and weight of biomass. To identify the ideal feed rate and speed of thresher capacity assessment, thresher data such as threshing capacity (kg), threshing efficiency, and time feed rate (kg) were closely recorded.

Table 2*. Engineering properties of harvested tef (Boset variety).*

Variable	Mean	Sensitivity to shattering
Plant length (cm)	104±69	Medium
Speck length (cm)	32±94	Medium
Chaff length (cm)	12±8	Medium
Chaff output (kg)	33.12	Medium

During the teff thresher's evaluation, we chose a split plot design with biomass as the treatment during performance evaluation where fed rate of thresher was 600, 700, and 800 kg per hour and drum speeds of 1000 rpm, 1100 rpm and 1200 rpm. These thresher speed trends were used for testing tef on a multi-crop thresher (Kidanemariam, 2020). All three replications were conducted 27 times. The threshing capacity was significantly impacted by both the feed rate and drum speed ($p < 0.05$) (Table 3). Threshing capacity is also significantly impacted by the interaction between feed rate and drum speed. During performance evaluation, the data collected was based on the parameters and evaluation results. The final result was compared with a developed equation based on dimensional analysis. It was also for food consumption that the evaluation was conducted. Such practical testing strengthened the validity of the developed equations.

Figure 1*. Field performance test of tef thresher during testing at Awash Melkassa wake Tiyo.*

Table 3*. Anova of testing multi-crop thresher result on Tef Komcho variety.*

	df	df Sum sq	means sq	fvalues	Pr, (>F)
Feed rate (kg.h^{-1})	2	2627.0	313.48	6.4085	0.007913 **
Drum speed revolution per minute	2	23465.8	1732.91	35.4256	5.748e-07 ***
Feed rates (kg.h^{-1}) x Drum speed (rpm)	4	489.6	22.41	0.4582	0.0765358 **

With a fed rates of the thresher at 800 kg h^{-1} and a drum speed of 1200 rpm, the maximum threshing capacity is 234.22 kg h^{-1}. The lowest threshing capacity is 223.20 kg h^{-1} when the drum speed is 1000 rpm and the feed rate is 600 kg h^{-1} (Table 4). Drum speed and feed rate have a considerable impact on the outcome. These trends, like the feed rate, increase the thresher capacity (Abagisa *et al*., 2015).

Table 4*. Threshing capacity of multi-crop thresher.*

Drum speed (RPM)	Threshing capacity	Fuel consumption
1000	234.22±23^{a}	2.1494 ±3^{a}
1100	232.37±21^{a}	1984.8 ±^{ab}
1200	223.20±2^{b}	1992.21±^{ab}

From the Figure 1, the effectiveness of the thresher was assessed at various feed rates and drum speeds. The threshing capacity increases in tandem with the feed. The thresher's performance or capacity increases as the drum speed increases. The threshing capacity was significantly impacted by feds rates and drum spends, as indicated from the developed mathematical model equations. It is accurate based on the testing results. Once more, the model equation shows that fuel usage is directly correlated with threshing capacity.

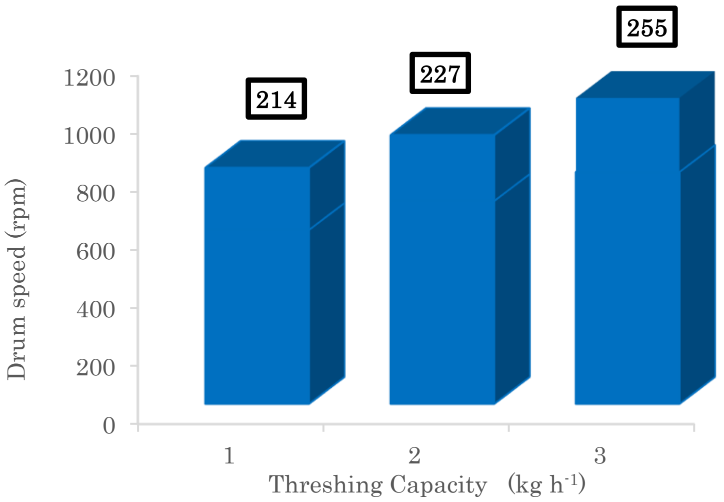

Figure 2. *Graph of thresher capacity at different speeds.*

As fed rates rise, so does threshing performance increases and fuel consumption also increases. These direct relationships in the model also show direct relationships when practically tested. Figure 2 represents the relationship between drum speed, thresher capacity, and fuel consumption. These three factors had a direct relationship during thresher performance testing. As the model is developed, the real testing is also directly proportional. As drum speed increases, the thresher capacity increases, and fuel consumption increases. These are the results of the relationship with pre evaluated by (Chaturvedi *et al.*, 2019).

Figure 3 represents the relationship between drum speed, thresher capacity, and fuel consumption. These three factors had a direct relationship during thresher performance testing. As the model is developed, the real testing is also directly proportional. As drum speed increases, the thresher capacity increases, and fuel consumption increases.

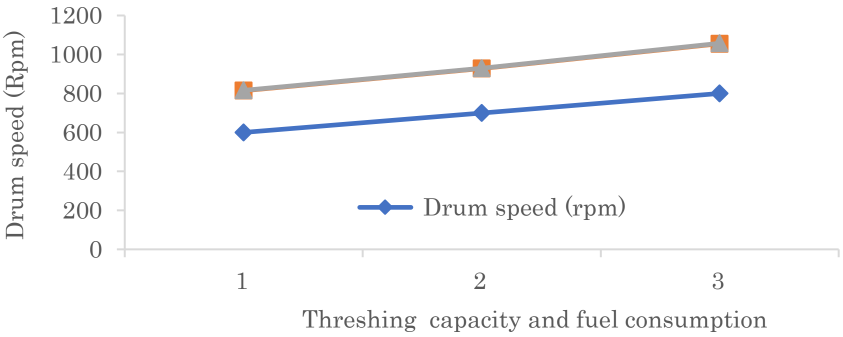

Figure 3. *Effect of feed on fuel consumption and threshing capacity.*

***Table 5**. Threshing capacity of thresher at different drum speeds and feed rates.*

Fed rates (k h^{-1})	Drum speds (rpm)	Capacity (kg h^{-1})	Fuel consumption (L h^{-1})
800	1200	250.43 ±21^{a}	2.245±12^{a}
700	1200	244.60 ±.4^{ab}	2.041±.3^{ab}
700	1100	235.02 ±3^{bc}	2.021±.8^{ab}
800	1100	233.96 ±42^{bc}	2.015±13^{ab}
600	1200	233.27 ±31^{bc}	2.012±.1^{ab}
600	1100	226.50 ±5^{cd}	2.007±.3^{b}
800	1000	218.26 ±3de	2.00±17^{b}
700	1000	217.53 ±42de	2.003±.8^{b}
600	1000	209.83 ±32^{e}	2.0023±.4^{b}

From Table 5, at 800 kg h^{-1} and 1200 rpm, the threshing capacity is 250 kg h^{-1} and fuel consumption are 2.245 L h^{-1}. At 600 kg hr^{-1} and 1000 rpm. The threshing capacity is 2.09 kg h^{-1} and fuel consumption is 2.00 L h^{-1} is so it had a direct relationship between feed rate, threshing capacity, and fuel consumption. Tef threshing was chosen after assessing the testing performance evaluation metrics. As cylinder speed increased as thresher capacity increased. The drum speeds increase with the space between the cylinder and concave clearance, and the thresher capacity decreases.

CONCLUSION

The study used dimensional analysis and the Buckingham pi theorem for threshers to construct a model for the thresher capacity and the fuel consumption equation. Good quality of thresher should be durable and easily constructed from available materials, should have good threshing capacity, good efficiency, ease to use or handle, efficiently used power, and best safety operation. The thresher capacity and fuel consumption equation take into account independent variables: cylinder radius (R), length of the cylinder (L), concave clearance (Cc), feed rate (Fr), drum speed (S), moisture content (Mc), crop straw ratio (R), spike/peg length PL, and crop bulk density (D). The equation and threshing capacity was (TC) is equal to $R^2 v\rho\,(\frac{L}{R}, \frac{L}{R}, \frac{Fr}{R^2VD},)\ MC^*\ SR$ and for fuel conception (F) is equal to $\frac{F}{R^2 v} = (\frac{L}{R}, \frac{L}{R}\ \frac{Fr}{R^2VD})\ MC^*\ SR)$ here is the model created for fuel consumption of stationary threshing performance process. $\frac{F}{R^2 v} = (\frac{L}{R}, \frac{L}{R}\ \frac{Fr}{R^2D})\ MC^*\ SR)$ this is the developed fuel consumption model for stationary thresher operation, $Fc = d^2 v\ (\frac{L}{d}, \frac{L}{d}, \frac{Fr}{d^2V\rho},)\ MC^*\ SR$ .The testing was conducted to check the relationship between the model's threshing capacity and fuel consumption. The multi-crop thresher's performance was tested and evaluated. As the dimensional analysis shows, the practical result has improved. So, to design a machine, understanding the analysis is the best way, with any complexity, to identify the relationship. The testing was conducted to check the relationship between the model's threshing capacity and fuel consumption. The multi-crop thresher's performance was tested and evaluated. As the dimensional analysis shows, the practical result has improved. So, to design a machine, understanding the analysis is the best way, with any complexity, to identify the relationship.

DECLARATION OF COMPETING INTEREST

The author declares that they have no conflict of interest.

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CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

The author declared that the following contribution is correct.

Tasfaye Aseffa ABEYE: Investigation, methodology, conceptualization, formal analysis, data curation, validation, writing-original draft, review, and editing, visualization etc.

ETHICS COMMITTEE DECISION

This article does not require any Ethical Committee Decision.

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