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RESEARCH ARTICLE

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MODIFICATION AND EVALUATION BAKOTEFF THRESHER TO TRACTOR 'PTO' OPERATION

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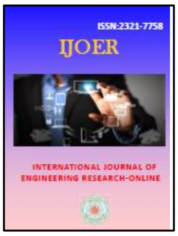


ABSTRACT

Commonly available teff threshers are engine driven, convectional drum type and primarily adapted to thresh teff only. The existing machine has eight long beaters bar, this cause un harmonized the force distribution system resulting in high increased vibration stresses, fixed concave that is only used for teff and less active threshing area. So to overcome the problems of existing teff thresher, this study was initiated with the objectives modify and evaluated the teff thresher machine to tractor PTO operation. Three levels of drum speed 700, 750 and 800rpm and 30Kg/min feeding rate were used to evaluate the performance of the machine at two different districts (Ambo and Gobu Sayo) of teff produce. Performance parameters such as threshing capacity (TC, Kg/hr), cleaning Efficiency (CE, %), and threshing loss (TL, %) were used to review capable achievement of the modified thresher. Based on the results obtained, the grand mean threshing capacity, cleaning Efficiency and threshing loss of 549.88Kg/, 92.68% and 4.18% is recorded for the adapted prototype; respectively. As compared to the previous thresher the modified one had more than 150 Kg/hr threshing capacity. Fuel consumption of 40lit was recorded for threshing 31.5kun of teff at Ambo district. Any users can used 750rpm drum speed in order to get high values of threshing capacity (572.13Kg/hr), cleaning efficiency (94.37%) and minimum threshing loss (2.62%) for any grain straw ratio of teff.
Keywords: Grain straw ratio, modify, performance, threshing,

Introduction

Teff is among Ethiopia's most important cereal crops. It is indigenous to the country and part of the culture, tradition and food security of its people. The crop is grown over approximately 2.8 million hectares or 27% of the land area under cereal production CSA, (1999). Teff is endemic to Ethiopia and its major diversity is found only in this country. According to Ponti, (1978) tef was introduced to Ethiopia well before the Semitic invasion of 1000 to 4000 BC.

Teff is grown by more than 6.3 million farming household and constitutes the major staple food grain for over 50 million Ethiopian people. This implies that teff is very vital in the overall national food security of the country.

The principal use of teff grain for human food is the Ethiopian bread 'Budena' a soft porous thin pancake with a sour taste. Teff contributes over two-thirds of the human diet in Ethiopia, with grain protein content (10-12%) like to other cereals. Teff proteins have non-gluten nature and owing to prevailing portion of prolamins belong to easily digestible ones, which make it appropriate option to wheat in the case of celiac disease and gluten-free diet. Besides providing protein and calories, it has high nutritional content, including better amino acid composition, especially lysine, more mineral content (mainly iron, calcium, phosphorus and copper) than other cereal grains, contain B1vitamin and is rich in fiber.

In Ethiopia, Teff research to date has focused mostly on breeding and improving agronomic practices, Mechanization have not been extensively researched; traditional methods of threshing Teff is done on flat ground called 'Odi' that is usually plastered by cow dung. The harvested Teff is spread over the 'Odi' and cattle/pack animals are driven over to separate the grain from the straw. In other ways, threshing is done by humans by beating the harvested Teff with a stick. Nevertheless, considerable yield losses are incurred during this process.

In addition, as the threshing is done on the ground, the quality of the Teff grain is affected as it can become mixed with the soil, sand and other foreign matter. This affects the market value of Teff significantly as Teff becomes polluted by the foreign matter, particularly minute grains of sand and soil, which are difficult to clean and cause discomfort during the consumption of 'Budena'(www.ata.gov.et).

Teff threshing process, in Ethiopia is traditional, is consume high man-hour with the associated fatigue, tedious and low output. Also, the crop is mixed with dirt, stones, and animal feces, making it unclean and unhealthy, and much grain is left on the stalk. As to the information obtained from the peasants, pre- and post- harvest losses goes for more than 40% of yield loss in Teff. (ATA; Teff Diagnostic Report, 2011).

The above saying is due to the lack of Teff threshing technologies because Teff is endogenous crop of Ethiopia that reserves other foreign countries to introduce threshing machine and Teff has no recognition as crop and important nutrition crop to the world. Bako and Asella Agricultural Mechanization Research Center's multi crop thresher were initially developed, modified and adopted for multi crop thresher within the center since 1989 G.C and intended to thresh barely, wheat and teff crops.

The multi crop thresher adapted and modified by Bako Agricultural Engineering Research center, Asella Agricultural Engineering Research center and Selam Vocational Training School types of multi crop thresher only threshes teff crop but does not clean the grain fully as required quality on the market, this leads our farmers for additional cleaning process such as using winnower machines for cleaning and investment labour cost for traditional method of cleaning process of threshed teff which is made by waiting natural air, throwing the threshed grain to the air to separate the grain from the chaff and the dust. The other traditional method cleaning process is creating artificial air by "Afarsaa" which made up of animal hide and "Gundoo" circular fat made up of hay or grass. So that using multi crop thresher to thresh teff doesn't alleviate the tedious work of traditional teff cleaning process which is the cause significant teff grain loss.

To solve the problems mentioned above, Bako Agricultural Engineering Research Center was developed complete teff threshing machine to overcome teff threshing and cleaning challenges, thereby decreasing tremendous teff grain postharvest loss because of traditional method of threshing and cleaning, due to lack of solely threshing machine of this Ethiopian golden crop.

The machine was evaluated at three drum speeds and feed rate. The threshing capacity of the machine is increased from 314.1 to 448.2kg/min as drum speed is increased from 700 to 800 rpm at constant feeding rate of 23kg/min respectively. The threshing efficiency of the machine is increased from 98.460 to 99.661% while the drum speed increase from 700 to 800rpm at feeding rate of 23kg/min. The threshing efficiency of the machine is decreased from 98.460 to 97.56% at drum speed of 700rpm and increased feed rate from 23 to 28kg/min, respectively. Total grand mean seed losses of 3.468 % was achieved at feeding rate ranging from 23 to 28 kg/min and drum speed ranging from 700 to 800 rpm (Merga, 2016).

The existing machine has eight long beaters bar, this cause un-harmonized the force distribution system resulting in high increased vibration stresses

Additionally, this arrangement cause less active area related to the drum diameter and length due to the reason mentioned above (Syed A.A. *et al.,* 2013). According to the author mentioned above this type drum beater arrangement high significant different on threshing capacity, efficiency and percentage of loss compare to the newly to be modified prototype. So to overcome the above problems, this study was initiated with the objectives modify and evaluated the existing teff thresher machine to tractor PTO operation.

Material and Methods

Modification of the machine was done at Bako Agricultural Engineering Research Center. After the prototype was modified the preliminary tests was done at the center while its performance evaluation was done at purposely selected districts of Ambo (Goda Gundo kebele) and Gobu Sayo (Ano Agro Industry) in West Shoa and East Walaga Zone of Oromia Regional State, respectively.

Material

The material used for prototype production were: square pipe, pulleys, angle iron, sheet metal, bearings, steel shaft, bolts and nuts, electrodes, flat iron, round bars, water pipes, sieves and teff. The instruments used during performance evaluation and data collection were: digital balance, spring balance, tachometer and stopwatch.

Machine Description

Modified tractor PTO operated teff thresher has the following parts. These parts are feeding table, threshing unit, cleaning unit, grain discharging unit, straw and chaff discharging unit. Threshing drum is made up of rolled and bar flat irons, mild sheet disks and steel shaft at the center.

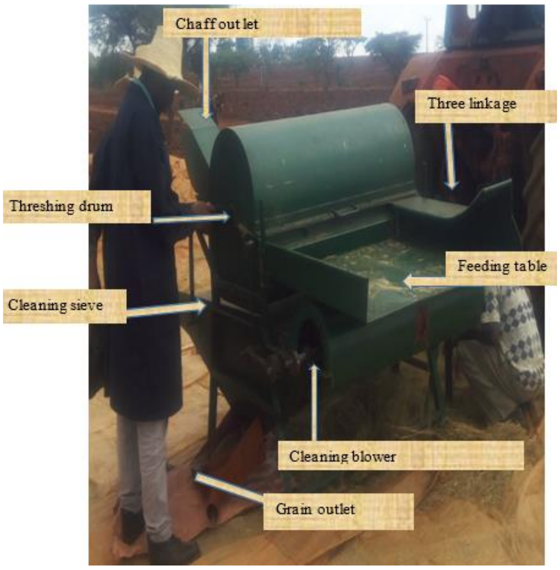


Figure1. Major parts of modified tractor operated Bako Teff thresher

The threshing Parts Modified

Threshing drum

Threshing drum is made up of rolled flat iron and steel shaft at the center. It has pegs through its length and flat blades that attached on at the end the drum. Peg has attached on threshing drum with helical arrangement for facilitating forward straw motion and biting. Each beater bar was divided into two equal pieces giving rise to evenly distributed sixteen beater bars instead of eight long bars in the conventional thresher. This redesigning of beaters and redistribution of beater bars resulted in better distribution of force and reduced impact load. And also the modified beater/bars facilitated repair as the shorter bar was easily and economically replaceable. Additionally, the new system also harmonized the force distribution system resulting in decreased vibration stresses (Syed A.A. *et al.,* 2013).

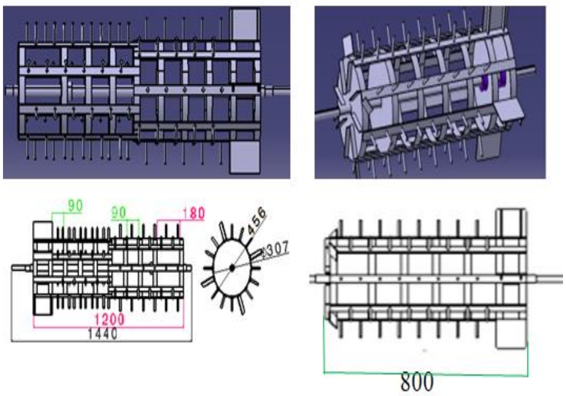
The principal parameters of the threshing drum are the drum length, the drum diameter, number of beaters on the drum and the drum speed (Soja *et al.,* 2004).

$$Q = q_o \, x \, L \, x \, M$$

Where:- Q = Feed rate of thresher (kg/s), q_o = Permissible feed rate (kg/s. m) and varies between 0.35 – 0.4,

L = Drum length (m) and M = Number of (rows of) beaters.

The thresher was modified as follow: drum length increased from 800 mm to 1200 mm,. From equation above, drum length and threshing capacity has direct relation between them so that increasing drum length increases the threshing capacity of machine.



(a) (b)

Figure 2. a) Modified drum part (all dimensions are in mm) b) The Existing Drum

Concave

Concave is the lower half of the drum which was served as the discharge through holes for the threshed teff, made of 8mm sieve hole diameter and also it was exchangeable. The existing concave was made of deformed round bar of diameter 8mm, 10mm spacing and also it was fixed to the frame. The clearance between threshing drum and concave was 30mm and length of the concave was also increased from 924 to 1257 mm. The upper half concave was used as top cover and it was made from rolled sheet metal and has helical welded sheet metals served as a chopping and cover for the crop material during threshed.

Fan

The air blast created by fan pushes the straw and dust out of the threshed grain falls on sieves. It has four blades attached to flat iron mounted on fan shaft that supported by two bearings on each end side to allow free rotation. Diameter of the fan is 370mm and its length is increased from 775 to 1210mm. For agricultural applications, fan speeds are recommended to be between 450 and 1000 rpm (Adane, 2004).

Selection of Drive and Transmission

Selection of pulley Diameter

The machine required four pulleys; two driven pulleys were mounted on the cylinder shaft while one pulley was on fan shaft and double grooved driving pulley is transmit the power from tractor PTO shaft to drum pulley. Due to its availability and cost aluminum and cast pulleys were selected. The diameter of the pulley used that take the power from tractor PTO shaft and transmitted to drum pulley was assumed 350mm.

Based on the required revolution per minute, the diameter of driven pulley was determined by Aaron, 1975.

$$N_1 X D_1 = N_2 X D_2$$

Where: N_1 = maximum speed of driven pulley, rpm; N_2 = speed of driving pulley, rpm; D_1=dia. of driven pulley, mm; D_2=dia. of driving pulley, mm.

With N_1 = 900 rpm, N_2 = 540 rpm(PTO speed) and D_2 = 350 mm, was used to calculated the diameter of driven pulley of cylinder, diameter of 210mm was computed and cast pulley was selected. While, with N_1 = 1200 rpm, N_2 = 900 rpm and D_2 = 120 mm, was used to calculated the diameter of driven pulley of fan shaft and 90mm was computed then, aluminum pulley was made in the center.

Selection of belt

Two belts were used to transmit power from Pulleys that takes power at tractor PTO to the cylinder shaft then transmitted to fan shaft. The length of belt was calculated using equation given below (Khurmi and Gupta, 2004).

$$L_p = 2C + 1.57(D_p + d_p) + \frac{(D_p - d_p)^2}{4C}$$

Where: L_p: effective length of belt (mm); C: center distance (mm); D_p: pitch diameter of driven pulley (mm); d_p: pitch diameter of driving pulley (mm).

The center distance was determined according to Maciejczyk and Zdziennicki, 2000 and designed distance between driving and driven pulley center of the machine.

$$\frac{(D_p + d_p)}{2} + d_p \le C \le 2(D_p + d_p)$$

Center distance = 580 and 790 mm taken value, 2048 and 1910 mm length of belt was computed for cylinder and fan respectively. The nearest standard pitch length is 2057 and 1905 mm for cylinder and fan respectively. From, the nearest standard pitch length for standard V-belts, B - 81 and 75 were selected for cylinder and fan respectively.

V-belt and pulley arrangements were used in this work to transmit power from the tractor PTO shaft to the drum then fan shaft. The main reasons for using the v-belt drive was its flexibility, simplicity, and low maintenance costs. Additionally, the V- belt has the ability to absorb shocks there by mitigating the effect of vibratory forces (Khurmi and Gupta, 2005).

Bearing Selection

Bearing selection was made in accordance to American Society of Mechanical Engineers (ASME, 1995) standard as given by Hall *et al.* (1988). Therefore, UCP of 206 and 204 bearing were selected for drum and fan shaft respectively.

Working Principle

The crop material put on the feeding table is pushed into the inlet of drum when tractor PTO shaft put on. The drum which gets power from a PTO shaft rotated in the concave is used to thresh the crop material. As the crop threshed, grain passes to grain outlet and straw to straw outlet. The grain passed through a concave fall on sieve and discharged to outside the machine. The straw, chaff and unwanted materials are passed to straw outlet by the help of chaff blade that was at end of drum and small broken chaff and dust was removed by air pressure created by blower. Blower and drum shaft consist of pulleys at one of their end and pulleys on each shaft are connected together with the help of belt to transmit power to each shaft.

Collected Data

The following data were collected during performance evaluation of modified Bako teff thresher to PTO shaft operated. Technical specification, threshing capacity, cleaning efficiency, grain– straw ratio and threshing loss were collected.

Performance Evaluation of Thresher

The following parameters were determined through performance evaluation tractor operated modified Bako teff thresher. Some of these parameters were: threshing capacity, cleaning efficiency, percentage of loss and threshing efficiency.

Threshing capacity (kg/h) $= \frac{W_g}{t} \times 60 \min/hr$

Cleaning efficiency $= \frac{W}{W_O} \times 100$

Percentage of loss (%) $= \frac{W_l}{W_l + W_g} \times 100$

Where:- Tc- threshing capacity (kg/hr), W_g – Weight of threshed grain at grain main outlet (kg), t – Recorded time of threshing (min), W = Weight of grains from the main output opening after cleaning, kg. W_O= Weight of grains and small chaff from the main output opening, kg, W_l = Weight of grains at front of sieve, kg, W_g= Weight of threshed grain at main outlet, kg.

Grain-Straw Ratio

Grain-straw ratio was determined by taking the sample of material that was threshed. The samples was weighed before threshed by hands to separate the grains and straw then grain was cleaned carefully and weighed and recorded to respective districts. The amount of straw was calculated by subtracts grain from the sample weighed.

Statistical Analysis

Three levels of drum speed 700, 750 and 800rpm by adjusting the position of fuel control throttle of the engine, 30Kg/min feeding rate and two different districts (Ambo and Gobu Sayo) teff produced were used to evaluate the performance of the machine. Grain straw ratio of teff used at Ambo and Gobu Sayo district was 1: 1.24and 1: 1.58, respectively.

The data were subjected to analysis of variances following a procedure appropriate for the design of the experiment (Gomez and Gomez, 1984) and using GenStat 15th edition statistical software. The treatment means that were different at 5% levels of significance were separated using least significant difference (LSD 5%) test. The least significant difference (LSD) test was performed for the mean values of threshing capacity, cleaning efficiency, threshing loss in relation to crop of different districts and threshing drum speed levels.

Results and Discussion

This study was undertaken to modify and evaluate existing thresher to a tractor PTO shaft operated thresher that able of threshing teff at three and two levels of drum speed and grain straw ratio of crops respectively. Performance parameters such as threshing capacity (TC, Kg/hr), cleaning Efficiency (CE, %), and threshing loss (TL, %) were used to review capable achievement of the modified thresher. The result obtained were analyzed and discussed as follows.

Performance of the Prototype Machine

Threshing capacity (Kg/hr)

ANOVA table indicated that the threshing capacity of the thresher was significantly ($p < 0.05$) affected by drum speed. Maximum threshing capacity of 667.86 and 510.11 kg/hr was recorded when the cylinder speed was 800 rpm for Ambo and Gobu Sayo district respectively. Grand mean threshing capacity of the machine was 549.88Kg/hr. Generally, threshing capacity has direct relationship with drum speed and grain straw ratio. Average threshing capacity of the machine from both districts has been the same trends. A. Vejasit and V. M. Salokhe (2004) had earlier reported that increase in drum speed increased threshing. The same trends also obtained by Adekanye, T. A., A. B. Osakpamwan, and I. E.Osaivbie. 2016.

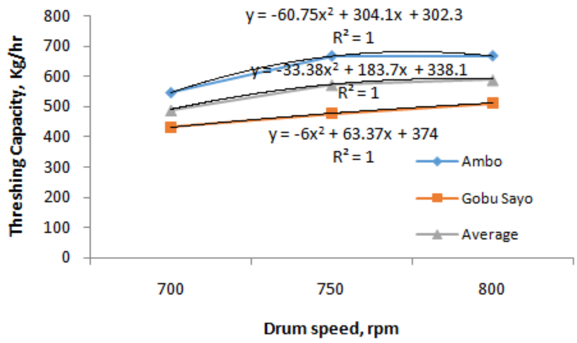


Figure3. Effect of drum speed on threshing capacity

Cleaning Efficiency (%)

ANOVA table indicated that the cleaning efficiency of the thresher was not significantly ($p < 0.05$) affected by drum speed and location. Maximum cleaning efficiency of 92.36 and 96.38 % was recorded when the cylinder speed was 750 rpm at Ambo and Gobu Sayo district respectively. Over all mean cleaning efficiency of the machine was 92.68%. Generally, cleaning efficiency has direct relationship with drum speed up to optimum speed then decline. This result has the same trend as that of Afify *et al.*, 2007.

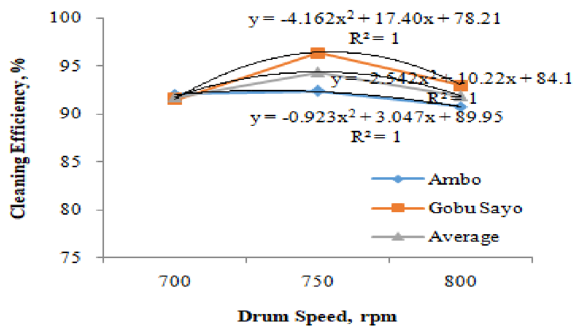


Figure 4. Effect of drum speed on cleaning efficiency

Threshing loss (%)

ANOVA table indicated that the threshing loss of the thresher was significantly ($p < 0.05$) affected by drum speed and also combination effects of drum speed and location. Minimum threshing loss of 0.33 and 4.91 % was recorded when the cylinder speed was 750 rpm for Ambo and Gobu Sayo district, respectively. Higher threshing loss was recorded at 700 and 800 drum rpm due to un threshing at 700 rpm and go with chaff throughout let at 800 rpm. Over all mean threshing loss of the machine was 4.18%.

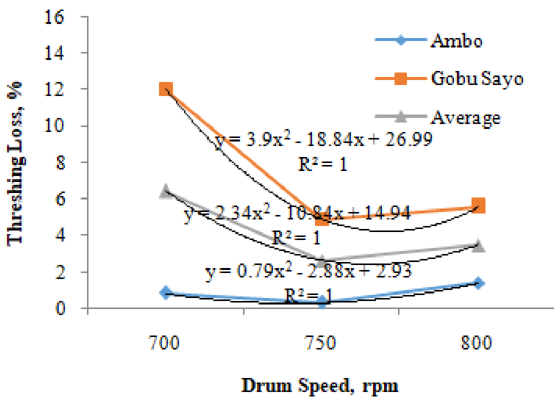


Figure 5. Effect of drum speed on threshing loss

Analysis variance of the performance of the machine

Source of variation	df	F value		
		Threshing capacity (Kg/hr)	Cleaning efficiency (%)	Threshin g loss (%)
Rep	2			
Velocity (V)	2	0.005*	0.191ns	0.026*
Locations	1	<0.001**	0.157ns	<0.001**
V X Locations	2	0.451ns	0.343ns	0.028*

** Highly significant at 1% level; * significant at 5% level; ns, non- significant; df, degrees of freedom.

Conclusion and Recommendations

Conclusion

Modification of Bako teff thresher to tractor PTO operated was done and its' performance evaluation was conducted under farmers' field. The following conclusions are drawn from the study. Performance evaluation of the thresher performed at different district (Gobu Sayo and Ambo district) teff produced that has grain straw ratio of 1:1.24 and 1:1.58 respectively. Maximum threshing capacity of 667.86 and 510.11 kg/hr was recorded at cylinder speed of 800 rpm at Ambo and Gobu Sayo districts, respectively. While, maximum cleaning efficiency of 92.36 and 96.38 % was obtained at drum speed of 750 rpm at Ambo and Gobu Sayo districts, respectively.

As compared to the previous thresher the modified one had more than 150 Kg/hr threshing capacity. Fuel consumption of 40lit was recorded for threshing 31.5kun of teff at Ambo district. Minimum threshing loss of 0.33 and 4.91 % was recorded when the cylinder speed was 750 rpm for Ambo and Gobu Sayo district, respectively.

Recommendation

From the obtained result modified tractor PTO shaft operated thresher was more effective than the previous thresher for its capacity and suitability of operation. Any users can used 750rpm drum speed in order to get high values of threshing capacity (572.13Kg/hr), cleaning efficiency (94.37%) and minimum threshing loss (2.62%) for any grain straw ratio of teff.

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