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Development and Evaluation of Teff Threshing Machine

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***Abstract* - Teff provides over two-thirds of the human food in Ethiopia, with grain protein content (10-12%) similar to other cereals. In Ethiopia, Teff research to date has focused mostly on breeding and on improving agronomic practices, Mechanization have not been widely researched; conventional methods of threshing Teff crop is done on special flat ground called 'obdi' that is usually plastered by cow dung. Nevertheless, considerable yield losses are incurred while threshing. The Teff threshing process traditionally is tedious, labor demanding, and most of the time cause of children out of school while harvest and threshing. Beside to this, as the threshing is done on the ground, the quality of the Teff crop is affected as it can become mixed with the soil, sand and other contaminants. This affects the market value of Teff significantly as Teff becomes polluted by the foreign matter, predominantly minute grains of sand and soil, which are not easy to clean and cause discomfort the consumption of 'Budena' (www.ata.gov.et).**

Generally that is why Bako Agricultural Engineering Research Center developed complete teff threshing machine to overcome teff threshing and cleaning challenges, thereby decreasing tremendous teff grain post-harvest loss because of traditional method of threshing and cleaning, due to lack of solely threshing machine of this Ethiopian golden crop. The thresher was evaluated and tested at drum speeds of 700, 750 and 800 rpm and feed rates of 23, 25 and 28 kg/min. Split plot method of experimental design was used and the variables were replicated three times and total of 27 observation were used to analyze data. The results showed that the minimum total grain losses of 2.706 %, threshing efficiency of 99.250% and cleaning efficiency of 99.028 were recorded under drum speed of 750 rpm and feed rate of 23kg/min.

Key words: Cleaning Efficiency, Teff, Threshing Capacity, Threshing Efficiency, Separation Lose

1. INTRODUCTION

The grain teff (Eragrostis teff [Zucc.] Trotter) is one of the major cereal crops of Ethiopia, where it is thought to have originated. It is the most popular cereal grain for making "Budena", which forms the traditional basic diet in Ethiopia, even though other crops such as sorghum, maize, barley, wheat and finger millet are sometimes used. Teff has the biggest share of area (23.42%, 2.6 million hectares) under cereal cultivation and third (after maize and wheat) in terms of crop production (18.57%, 29.9 million quintals) in Ethiopia (www.ajfand.net).

During the *Belg* season, which is the autumn season in Ethiopian (from February to the end of May) Teff, is grown in very restricted areas and occupies less land. As the Central Statistical Office, 1996, Teff holds 6.40 percent against cereals and the total production share is 4.33 percent, showing that Teff is predominately a major season crop. Teff is also an export grain. The grain was exported to the Middle East, North America and many European countries, mainly for Ethiopians.

It is grown by morethan 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 o verall 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. "Budena" is made from flour, water and starter "Rachati". "Rachati" is a fluid saved from previously fermented dough. 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 a 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 fibre.

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 'Obdi' that is usually plastered by cow dung. The harvested Teff is spread over the 'Obdi' 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).*

The Teff threshing process traditionally is tedious, time demanding, and often keeps children out of school while threshing. 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. Oromo's people are saying "Hamma ani badu otoo beekanii na facaasanii" jette taafiinii. Meaning "Had they known how much of me is lost, they would not have saw me" said 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.

From survey conducted there is no threshing machine which solely thresh teff in Ethiopia. The multi crop thresher adapted and modified by Bako Agricultural Mechanization Research center, Asella Agricultural Mechanization 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.

Generally that is why Bako Agricultural Mechanization Research Center developed complete teff threshing machine to overcome teff threshing and cleaning challenges, thereby decreasing tremendous teff grain post-harvest loss because of traditional method of threshing and cleaning, due to lack of solely threshing machine of this Ethiopian golden crop.

2. MATERIAL AND METHOD

Manufacturing of the machine and test was made in Bako and field experiments and data collection were carried out during the planting season of 2014 and 2015 G.C in one of the teff belt West Shoa zone Dandi woreda.

2.1. MATERIALS

- Threshing machine: The threshing machine was designed and manufactured for threshing teff crop in Bako Agricultural Mechanization Research Center.

- KAMA Engine

KAMA engine was used to operate the thresher

Technical Specification of KAMA Engine

Model	186F
Type	Single cylinder ,vertical, 4-stroke, air cooled, direct injection
Normal speed (rpm)	3000-3600
Normal power	7.76-8.57 hp
Fuel tank capacity (L)	5.5
Lubrication capacity (L)	1.65
Starting type	Recoil manual start
Weight (kg)	53

- Stop watch: of 0.02 sec. to record the threshing time.

- Tachometer: (VICTOR-DM6236P), ranged from 60 to 19999 rpm, resolution 1 rpm to calculate the rotating speed of drum.

- Electric balance: of 0.01 g as accuracy to estimate the seed losses.
- Electric oven: to estimate the moisture content.

2.2. METHODS

In the first phase necessary information were collected in regard with teff threshing problems and the drudgery work of teff threshing traditionally that causes the tremendous grain and quality lose due to traditional teff threshing process and further discussion with concerned body was made. To start the work the availability teff threshing technologies were surveyed.

Different thresher prototype were assessed and the two multi crop thresher, Asella model and IITA type multi crop thresher were determined that they are also threshing teff and also IITA multi crop thresher prototype was brought to the center from Ano Agro Industry to examine the mechanism of threshing and design thoroughly. So that identifies the design which meets best teff threshing requirement. After reviewing all necessary parts required for threshing teff, design of all parts were prepared. In line with this material and equipments were ready to manufacture the prototype.

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2.2.1. DESIGN CONSIDERATIONS

The following were considered in the design of the Machine; ability to thresh teff with insignificant loses than the traditional method of threshing and cleaning, ease of operation, reduction of the energy requirements and the drudgery involved in the traditional methods of threshing, economy to make the machine affordable and within the capacity of the local farmers and the choice of materials for the development of the machine to reduce the total energy requirements

2.2.1.1. Drum

The threshing drum is housed in the concave and drum cover which was made from a peg type beater of 300 mm in diameter and 800 mm long. The pegs were made from deformed round bar 10mm in diameter 62mm long and chaff scupper at the out let side which used to throw as well as blow the chaff. The peg type or rasp bar drum is best to thresh teff, chop the chaff as required for animal feed and plastering residence and also separate the grain from the chaff so that allow the grain to fall down to the concave.

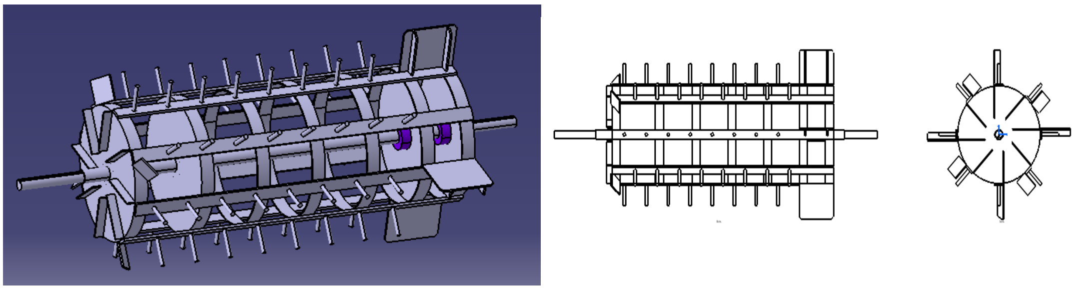


Fig1. Peg type drum (beater)

2.2.1.2. Concave

concave part is used to house the drum (beater) from the bottom side of the threshing part which was made up of sheet metal of 3mm, deformed round bar of diameter 8mm, 4mm*40mm angle iron and sieve 5mm diameter hole also used to give opportunity for grain not to go with chaff at out let end. The concave was also made to have choppers which were made from flat iron and sickle shapes prepared from sheet metal of 1.5mm to assist the chopping action then after decreasing the wounding opportunity of the straw on the threshing drum and chop the chaff to the required. At the end of the concave length, sieve 5mm diameter was included lessen the opportunity of the grain going with the chaff.

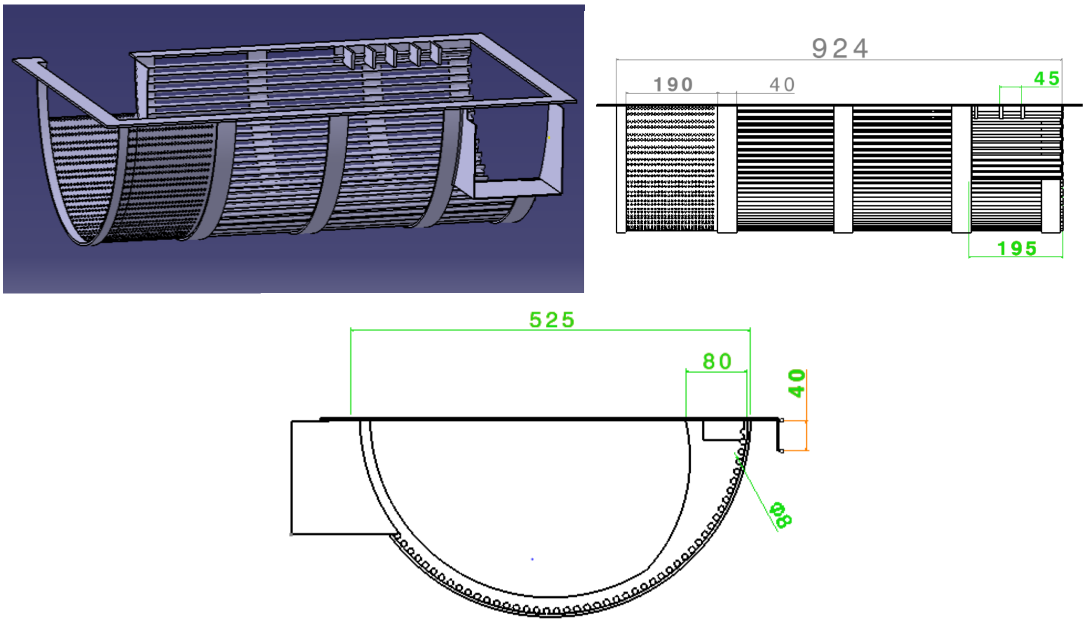
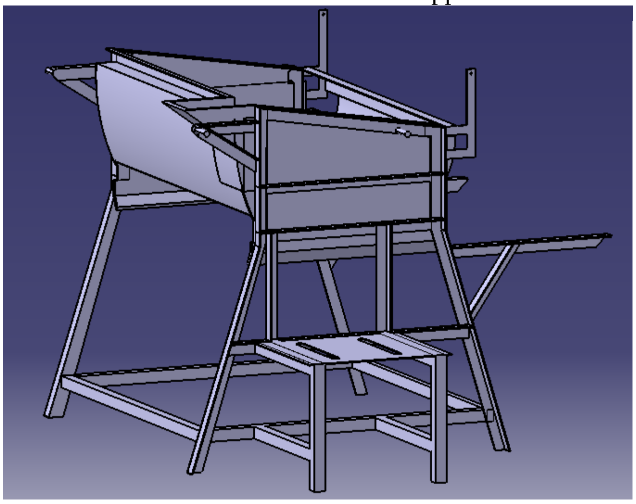


Fig2.concave part of thresher

2.2.1.3. Frame

The frame of the thresher was made up of 4mmx40mm angle iron, 1.5mm sheet metal, 4mmx40mm square pipe, and 16mm diameter normal round bar to support the sieving part. The frame also has the concave seat and concave cover on sides as well as the frame was made at angle to decrease the vibration.



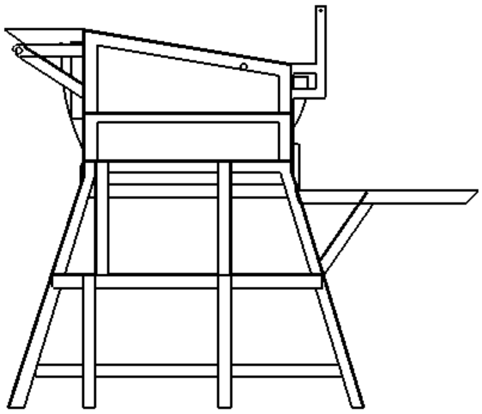


Fig 3 frame and engine seat

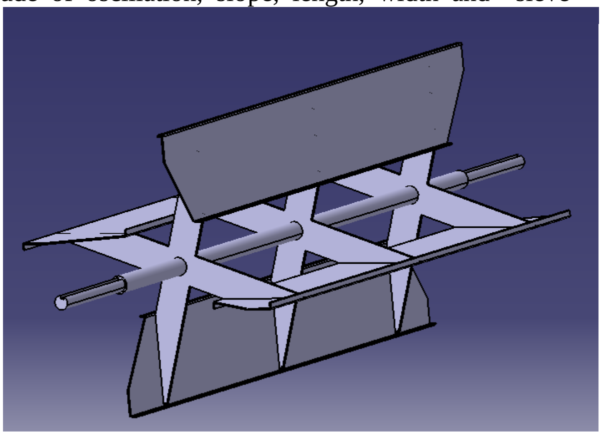
2.2.1.4. Cleaning part

Combination of Aerodynamic and Mechanical

Combined air and sieve system, used to separate grain from undesired materials, employs terminal velocity, size, shape, and density as a means to segregation and separation. The method is advantageous and effective than the others methods of separation. The primary method of grain separating and cleaning, at the moment, is the air-sieve separator (OARI, 2006/7). According to Simonyan et al. (2006) the physical parameters affecting the separating and cleaning process are classified into two: (i) crop factors that include crop variety, maturity stage, grain moisture content, straw moisture content, bulk density of crop, bulk density of straw, stalk length, terminal velocities of particles (both grain and other materials), grain size and (ii) machine factors such as frequency of sieve oscillations, amplitude of oscillation, slope, length, width and sieve hole diameter and fan speed. Teff crop has high biomass such as chaff, dust and broken straw during threshing that makes it difficult to separate grain from foreign materials by using solely one separator.

2.2.1.4.1. Blower

Aerodynamic separator and cleaner use air as a medium to lift light materials such as chaff and dust out of mixture of grain and undesirable materials; i.e. heavier materials moving downward while light materials are blown away. The blower was designed to stream artificial air horizontally to blow out mixed product injected along the vertical plane. The blower was made up of 2mm sheet metal, 4mmx40mm flat iron, 25mm diameter steel shaft, 4mmx40mm angle iron, 1mm sheet metal to house the fan(blower), eccentric pulley to create oscillation motion and bearing with housing.



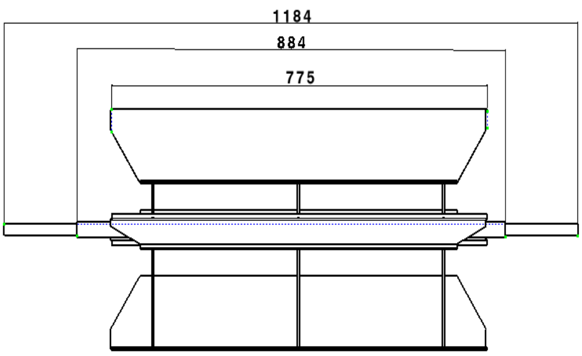


Fig4. Blower

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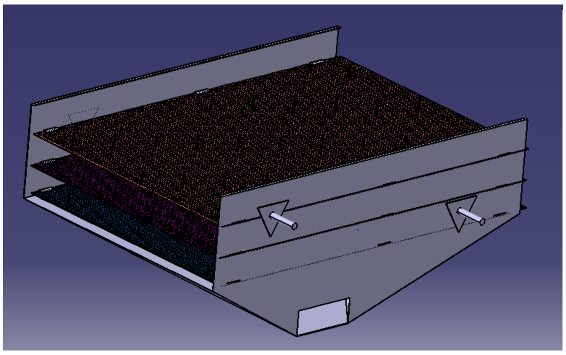
Vol. 5 Issue 11, November-2016

2.2.1.4.2. Sieves

In mechanical separation mixed materials are moved over a perforated and oscillating surface with openings of specified shape and size. Mechanical or sieve separation is a process separating the desired material/grain from undesired materials depending on their size and shapes. In this way three step sieves made from 1.5mm sheet metal, 1.5mm square pipe, 4mm, 3mm and 2mm hole diameter perforated sheet metal of 1.5mm thickness was included in the machine. The length of the sieve was made 1.2m to manage the size of the machine and the slope of the sieve is adjusted by moving the front sieve support up and down.



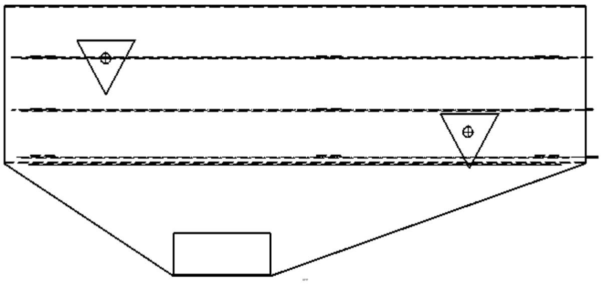


Fig5. Sieves and its compartment

2.2.1.4.3. Sucker

In addition to air blower and sieves sucker was also included in the thresher to further increase threshing efficiency of the machine. Since the huge part of threshed teff is broken straw and dust it is difficult to control all dust and foreign materials by sieves and artificial air steaming or blower. So that to acquire the clean and dust free teff grain sucker was attached at the grain out let the thresher. The sucker was made of 1mm sheet metal, 2mm sheet metal, 20mm steel shaft, aluminum pulley and cast pulley.

2.2.2. Prototype Development

After the design of each component parts of the machine has completed, material type and amount of the material required for manufacturing (development) of the machine was selected and purchased according to the schedule.

All necessary materials were procured and parts were manufactured separately in line with the design prepared for each part. The manufactured parts were assembled accordingly made ready for test. Center level test was made repeatedly and further modification was conducted on the machine generally, and on cleaning part particularly depending on feed back the test.

2.2.3. Physical property of teff crop

The harvesting activity of tef has starts when the growing crops in the field completely change their color to straw or yellowish. This phenological stage of the crop occurs 60-120 days after sowing depending up on growing period of the varieties and environmental conditions. The major indicators of maturity are changing of the panicle which holds the spikelet in to straw color. Early harvesting is advisable before the crop gets too dry and exposed to sever shatter which leads to high yield losses. The amount of loses during mowing of the crop is not yet determined through research but it is believe that much the volume of grains is lost through shaking when handling by hand for cutting. The safest moisture for storage is not specifically determined through research but as like other staples it is estimated to be 12%. It usually dries naturally while in the field and does not require artificially heat for harvest. Tef is harvested after the seeds are physiological mature and dried. The seeds do not have dormancy right after harvest and if there is adequate moisture it can be germinate immediately after harvest. Mowing is done by holding the bundle of plants in the left hand and cutting them on the right hand with sickle 5cm above the ground. The bundles in the hand after mowing are placed collectively in the ground. Farmers are usually left the bundles without tied in the ground until harvesting is finalized on the entire field and following completion of harvesting, all bundles scatter in the field are heaped together until threshing.

2.2.4. Operational Principles of the Thresher

The machine threshes the teff crop by hammering action. The teff is fed by manually pushing teff stack into the threshing cylinder. The cylinder rotates anticlockwise, beat the stack until it is threshed. The knife part on the top cover and used to chop the stack to the required size straw and chaff as well as protect the stack of teff not to wound on the drum of the thresher. At the end length of the drum or beater there is scooper that scoops and throw chaff and straw through the chaff out let. The threshed grain passed through the perforated hole on the sieve. As the threshed grain, broken stack and dust fall, they move across the air current cross flow wise. The since the broken stack is heavier than teff crop and dust it is separated mechanically by step sieves. The dust and teff crop are separated aerodynamically which is adjusted by pulley ratio and blown away while the teff crop drops to the delivery unit to be collected.

2.2.5. Test condition

The performance of the machine under test was vary in line with the variety and condition of moisture content of the tef and the way the machine was adjusted /operated. Measurement and observation was taken :

- Before testing
- During testing
- After testing

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 11, November-2016

Measurement before testing

- Moisture content of the teff (optimum)
- Variety of teff grain
- Weight of straw before threshing
- Adjustment of the working parts
- Revolution speed of the working parts

Measurement during testing

- Time record
- Sampling of teff grain
- Description of feeding method and labour requirement
- Description of breakdowns, repairs and replacements of parts
- Observation on the machine (effectiveness, vibration and noise,clogging or other deficiency of flow)

2.2.6. Measurement and calculation after testing

- Amount of threshed and unthreshed grain
- Damage loses and cleanliness(cleanig efficiency, threshing efficiency and percentage of blown grain)

Calculations

The following criteria by FAO (1994) were used to evaluate the performance of the threshing machine on threshing efficiency (TE), threshing capacity (TC), cleaning efficiency (CE) and percentage of loses.

2.2.6.1. Efficiencies

2.2.6.1.1. *Threshing efficiency (TE)*

It was calculated according to the following equation:

$$TE\ (\%) = \frac{\text{Mass of threshed crop (kg)}}{\text{Mass of threshed crop (kg)} + \text{Mass of unthreshed crop (kg)}} x100$$

2.2.6.1.2. Cleaning efficiency (CE)

It was calculated according to the following equation:

$$CE\ (\%) = \frac{\text{Mass of threshed crop (kg)}}{\text{Mass of threshed crop (kg)} + \text{Mass of dust within crop (kg)}} x100$$

2.2.6.1.3. Threshing capacity

It was calculated according to the following equation:

$$TC\ (kg/hr) = \frac{\text{Total Mass of threshed grain (kg)}}{\text{Time taken(hr)}}$$

2.2.6.2. Grain loses

2.2.6.2.1. Threshing loses

It was calculated according to the following equation:

$$DL\ (\%) = \frac{\text{Mass of unthreshed grain(kg)}}{\text{Mass of threshed grain(kg)} + \text{Mass of unthreshed grain(kg)}} X100$$

2.2.6.2.2. Separation looses

It was calculated according to the following equation:

$$SL\ (\%) = \frac{\text{Mass of goes with dust (kg)}}{\text{Mass of threshed grain(kg)} + \text{Mass of grain dust (kg)}} X100$$

2.2.7. Testing and Performance Evaluation

Performance evaluation was carried out on the teff threshing machine to determine the effects of the threshing speed on the threshing efficiency, threshing capacity, cleaning efficiency and percent of lose.

The site was selected in Eastern Oromia zones which has potential of teff production areas generally and West Shoa zone Dandi woreda particularly. The heaped teff with optimum threshing moisture content was identified and selected. The functionality of the machine was seen and adjustment malfunctioning parts was inspected and readymade for test and performance evaluation.

The cereal grain teff (Eragrostis tef [Zucc.] was weighted to determine the optimum feeding rate, and were fed into the machine. The output from the seed outlet and the chaff outlet were collected and weighted. Unthreshed teff were threshed manual with stick and the seeds taken out and weighted using sensitive weighting balance. Three drum speeds of 700 rpm (14.67 m/s), 750 rpm (15.69 m/s), 800 rpm (16.75 m/s) were used and this speed out from drum shaft was transmitted to a pulley on the blower shaft to assist the cleaning action of the cleaning part.

International Journal of Engineering Research & Technology (IJERT)
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Vol. 5 Issue 11, November-2016

(a) (b) (c)

Fig (6) thresher test and performance evaluation (a), falling down of teff heap (b), and data collection (c)

Three feeding rates of 12 kg, 15 kg and 21 kg at optimum moisture content were selected. Each combination of drum speeds and feeding rate were replicated three times and the representative value taken as the mean of the three readings resulting in a total of 27 observations (3 feed × 3 speeds × 3 observations). Means of the observations were taken and a split plot design was used with a total of 27 observations (3 drum speeds × 3 feed x 3replication).

3. RESULTS AND DISCUSSIONS

The effect of some operating parameters on seed losses

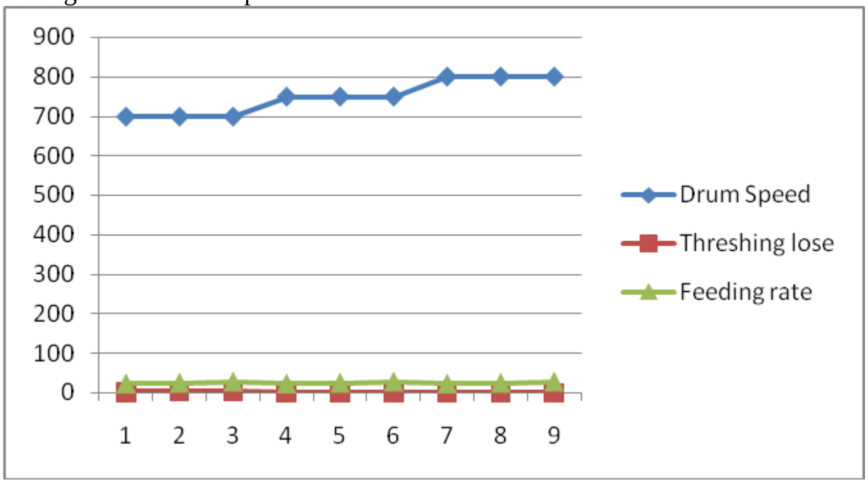
The threshing losses are affected directly by different operating parameters such as feed rate, threshing drum speed, etc.

3.1. Drum losses

Generally, the threshing losses expressed as drum losses which represent un-threshed seed losses increased by increasing feed rate and decreased by increasing threshing drum speed. From table of ANOVA drum or threshing lose is highly significant with drum speed and feeding rate and also significant with the combination of drum speed and feeding rate as well as not significant with replication and combination of replication with two independent variable at significance level of($p< 5\%$). Increasing feed rate from 23kg to 28 kg at drum speed of 700 rpm increased the drum losses from 1.564 and 2.501 respectively. The increase in the percentage of drum losses by increasing feeding rate is attributed to the excessive plants in the threshing chamber. Consequently, plants leave the device without complete threshing that tends to increase drum losses. While the vice-versa was noticed with drum speed. Increasing drum speed from 700 to 800 rpm at feed rate of 23 kg/min decreased the drum losses from 1.564 to 0.340% respectively. This decrease is due to the more adequate time to separate seeds from the straw. The result obtained agreed with Gol and Nada (1991) which concluded that the important factors affecting the efficiency of mechanical threshing element are operation speed and crop conditions. Percentage of threshing increased by increasing of peripheral drum speed.

R Square is 0.912

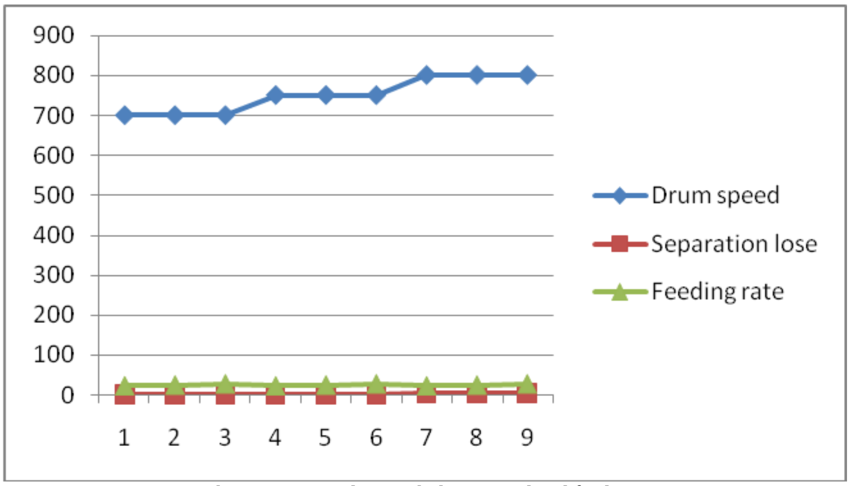
$y = 10.895 - 0.016*V + 0.088*F$ The regression shows that the coefficient feeding rate is which affect the drum loss and drum speed has negative correlation with drum loss.



Graph1. Threshing lose with feeding rate and drum speed

3.2. Separation loses

The separation losses increased by increasing both feed rate and drum speed. An ANOVA table show that separations lose is highly significant with feeding rate and drum speed. Increasing feed rate from 23 to 28 kg/min at drum speed 700 rpm, increased the separation losses from 1.25 to 2.035 respectively. This increase is attributed to the excessive plants in the threshing chamber, it gives the opportunity to the threshed plant to stay on the cleaning without blown in other ways while the drum speed is increased from 700 to 800 rpm the separation loses increase from 1.254 to 3.090 respectively 23kg /min feeding rate. When the drum speed is increased the shaking action of the cleaning part is increased that makes the grain thrown out, as well as assist the fan blower to blow the grain out.



Graph 2. Separation lose with drum speed and feeding rate

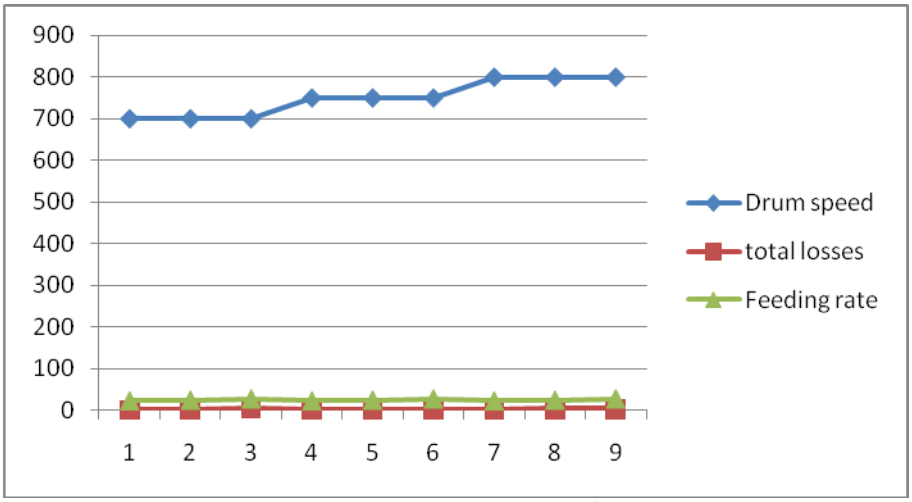
Also, increasing the drum speed from 700 to 800 rpm at feed rate of 23 kg/min increased the separation losses from 1.254 to 3.090 respectively. The increase in the percentage of separation losses by increasing drum speed was attributed to the high threshing and impacting forces applied to the plants.

The R Square of is 0.896

y = -13.261 +0.017*V +0.1*F from this regression equation separation loss is affected by both drum speed and feeding rate.

3.3. Total losses

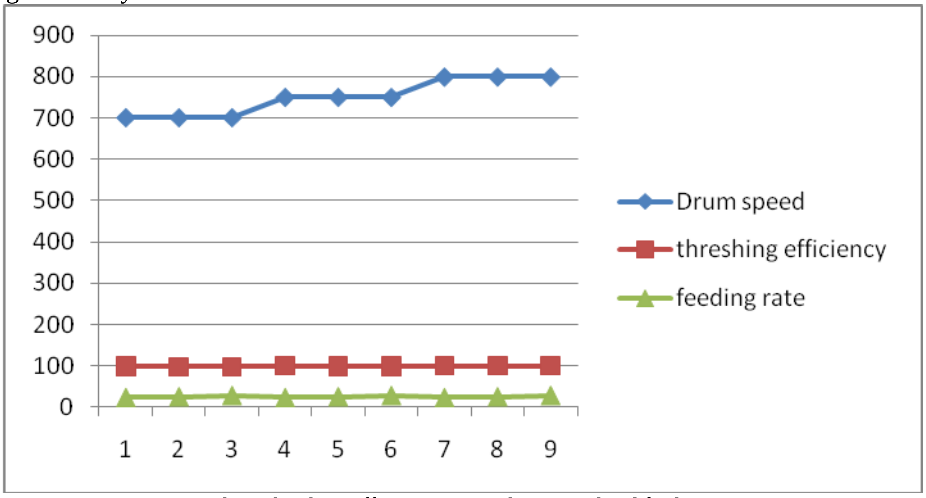
From the previous analysis results obtained, the total seed losses including both drum losses and separation losses were illustrated. It can be noticed that the total grand mean seed losses of 3.468 % was achieved at feeding rate ranging from 23 to 28 kg/min and drum speed ranging from 700 to 800 rpm. The result achieved is very good because it is below the recommended percentage of grain losses during threshing.



Graph3. Total losses with drum speed and feeding rate

3.4. Threshing efficiency

The threshing efficiency affected by different operating parameters such as feed rate and threshing drum speed. From ANOVA it is clear shown that threshing efficiency is highly significant with both feeding rate and drum speed. As shown in mean table or graph 4, increasing drum speed from 700 to 800 rpm, the threshing efficiency of the machine is increased from 98.460 to 99.661% at feeding rate of 23kg/min. As well as when the feeding rate is increased from 23 to 28kg/min at constant drum speed of 700 rpm, the threshing efficiency of the machine decreased from 98.460 to 97.56% respectively. The decrease in the percentage of threshing efficiency by increasing feed rate is attributed to the excessive plants in the threshing chamber. Consequently, the seeds leave the device without completely threshing the grain from the head. So that the grand mean of the threshing efficiency of the machine at the two independent variable range was 98.905%. ElHadad (2000) stated that the threshing efficiency increased with increasing drum speed and decreasing feed rate. R Square 0.915 ,y = 89.343 +0.016*V -0.085*F

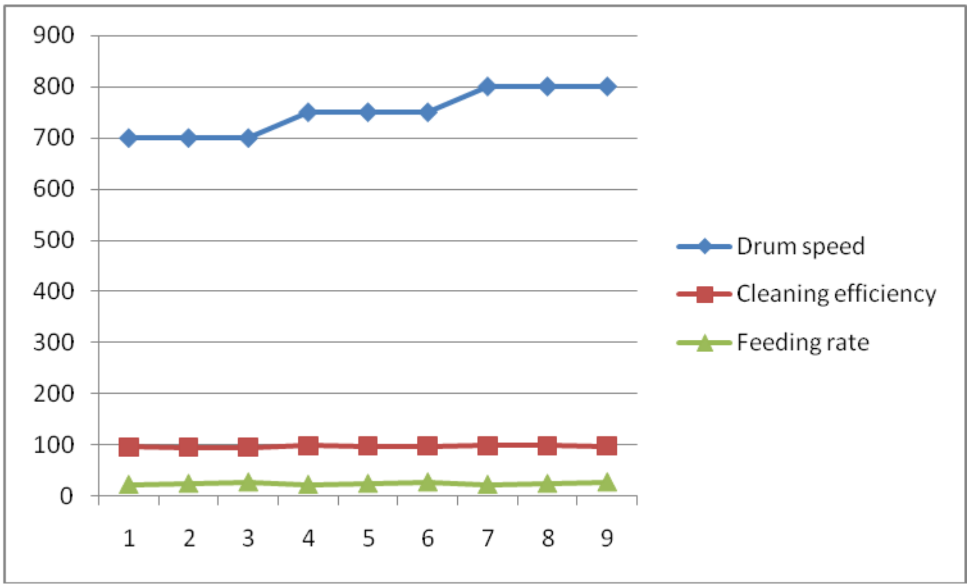


Graph4. Threshing efficiency versus drum speed and feeding rate

3.5. Cleaning efficiencies

Generally, the cleaning efficiencies increased by increasing the drum speed and decreased by increasing feeding rate. ANOVA table shows that, the cleaning efficiency is highly significant with both feeding rate and drum speed and also significant with the combination replication and drum speed.

Increasing the feed rate from 23 to 28kg/min at constant drum speed of 700 rpm cleaning efficiencies decreased from 96.725 to 95.692%, respectively. While, increasing the drum spe

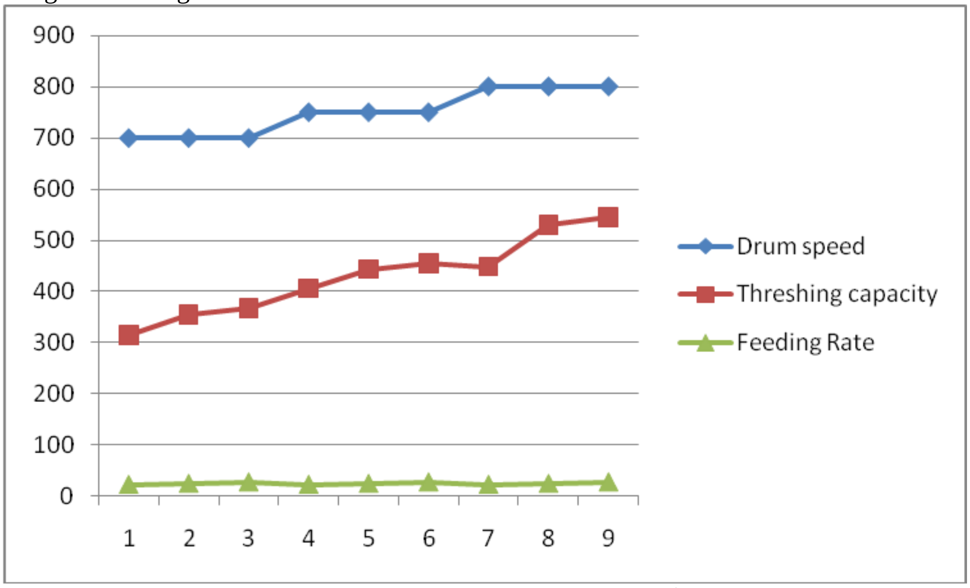


Graph (5). Cleaning efficiency versus variable drum speed and feeding rate

So that the cleaning efficiency of the threshing machine is highly affected by aerodynamic and hydrodynamic properties of the teff grain and non grain materials.

3.6. Threshing capacity (TC)

From ANOVA table the threshing capacity of the machine is highly significant with both drum speed and feeding rate and not significant with replication and any combination of the independent variables. As the feeding rate increased from 23 to 28kg/min at constant drum speed of 700 rpm the threshing capacity increased from 314.1 to 366.9kg/hr respectively. The total grand mean of threshing capacity of the machine is 428.9kg/min. The grain straw ratio of the crop highly affects the threshing capacity of the machine. During the performance evaluation of the machine the average grain straw ratio observed was 27%.



Graph (6) threshing capacity at range drums speed and feeding rate

As drum speed increased from 700 to 800 rpm at constant feeding rate of 23kg/min the threshing capacity of the machine increased from 314.1 to 448.2kg/min respectively. Increasing drum speed is attributed to the high threshing or beating force applied during threshing operation, that tend to consume more fuel and increase energy required.

4. CONCLUSION AND RECOMMENDATION

The teff threshing machine was developed and tested to thresh teff crop with high efficiency. The analysis data from the observation of the study led to the following conclusions:-

Minimum total grain losses of 2.706 % were obtained at feed rate of 23kg/min, drum speed of 750 rpm and maximum total grain loses of 4.536% was recorded at drum speed of 700 rpm at feeding rate of 28 kg/min. While the threshing and cleaning efficiencies of 99.250 and 97.529% were obtained respectively at feeding rate of 23kg/min constant drum speed of 750 rpm. The maximum drum lose was obtained at constant drum speed of 700 rpm which is 1.564, 1.992 and 2.501% at feeding rate of 23, 25 and 28kg/min respectively. Threshing efficiency of the machine is good at 750 rpm at feeding rate ranging between 23kg/min and 25kg/min which values 99.250 and 99.058% respectively and also does the cleaning efficiency of the machine which is 99.028 and 98.035% at the indicated feeding rate.

As recommendation, as far as the appearance of the machine seems very huge due to the inclusion of the step sieves which take large space, which open the way for improvement or modification to down size of the machine. The threshing capacity and efficiency of the machine is low when the moisture content of the threshed biomass is above the optimum of threshing moisture content of teff, which high energy input from the engine if not it can stop the engine operation. The drum speed of more than 800 rpm is not recommended to thresh teff crop because it can cause grate machine vibration that can damage of parts, and also high grain separation losses and grain straw under sizing. The transportation system is very difficult and need smaller tire or wheel to access transportation by trailing to the cart. The engine seat is flexible need further modification to manage the vibration thresher.

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