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Teff, Cleaning Efficiency, Threshing Capacity, Threshing Efficiency, Grain loss

Teff is the most important indigenous cereal crops of Ethiopia, where it is thought to have originated, despite its versatile merits, teff production processes are dominated by traditional methods. To solve one of its postharvest production problems, the traditional threshing and the resulted losses of quantity and quality, engine powered threshers have been developed by different institutions, including Asella Agricultural Engineering Research Center (AAERC). Nevertheless, as most of the existing machineries are constrained with low output and cleaning problems. An imported CAAMS teff thresher was evaluated and tested with the objective of evaluating its performances. The machine was tested at drum speeds of 800, 1000 and 1200 rpm and feed rates of 6, 8 and 10 kg/min respectively. From the test results, the grand mean of threshing efficiency, cleaning efficiency, threshing capacity, separation loss and fuel consumption of 100%, 97.34%, 2.511%, 111.32 kg/hr, 2.7% and 0.2 lit/hr were obtained, respectively. In addition, the result of statistical analysis showed that, the drum speed have significant effects on cleaning efficiency and separation loss, whereas the feed rate have a significant effects on threshing capacity.

One of the economical cereal crops in Ethiopia is teff. It is indigenous to the country and is a fundamental part of the culture, tradition, and food security of the people. This crop is gaining international recognition and acceptance and is a means of foreign currency earning in addition to its value as a food crop at home. Currently, teff is grown on approximately 2.80 million hectares of land which is 27% of the land area under cereal production. Teff accounts for about a quarter of the total cereal production and is a highly economical food grain in Ethiopia, approximately, 6 million households grow teff and it is the dominant cereal crop in 30 of the 83 high-potential agricultural Woreda (Bekabil et al., 2011). Teff accounts for about two-thirds of the daily protein intake in the diet of the population (Ethiopian Nutrition Survey, 1959). Teff has a high economic value as its grain can be kept for years without being seriously damaged by insects and pests in common storage (Tadesse, 1969).

Despite its versatile advantages and merits, teff production processes are dominated by traditional methods and tools, mainly due to lack of mechanization technologies for teff, as it is indigenous to Ethiopia. The traditional methods of harvesting, threshing and postharvest handling of teff usually lead into contamination of the product with stones, sticks, chaff, dirt and dust. Traditionally teff is threshed on prepared ground called 'Ogdii' which is made on gently slope ground smeared with cows' dung. Traditional threshing of teff crops is one of the times consuming, laborious, and significant grain loss occurs. The harvested Teff is spread over the 'Ogdii' 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 foreign matter, particularly minute grains of sand and soil, which are difficult to clean and cause discomfort during the consumption of 'Buddeena' (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 go for more than 40% of yield loss in teff. Oromo's people are saying "Hamma ani badu osoo beekanii na hin facaasanii" jette xaafinii. Meaning "Had they known how much of me is lost, they would not have saw me" said teff (ATA; Teff Diagnostic Report, 2011). Agricultural mechanization, which includes threshers in the form of combined machine and single act machine, is the process of using agricultural machineries to mechanize the work of agriculture, greatly increasing farm productivity. With regard to developing threshers for teff production, the single-acting engine-powered threshers have been developed and a number of farmers are also using them for the threshing and cleaning of teff in some parts of Ethiopia, including Oromia. Nonetheless, the existing machinery in the country are, all constrained with low output per hour and cleaning problems, which are mainly associated with the difficult nature of the teff to detach from its panicle and its high straw than grain to separate. Hence, to solve the problems associated with domestic threshers, the Ethiopian Ministry of Agriculture

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(MoA) imported a Chinese firm (Chinese Academy of Agricultural Mechanization Sciences) made teff thresher called CAAMS thresher, which is specifically designed for teff threshing and cleaning purpose. To verify its performance for threshing and cleaning purposes, MoA submitted the machine to Asella Agricultural Engineering Research Center (AAERC) to conduct farm-level tests and generate its performance data before the machine is passed to agricultural extension sections for promotion and distribution to Farmers.

Therefore, this activity was initiated with the objective of farm-level performance testing of the CAAMS teff thresher and to generate data on the effectiveness of the machine's threshing capacity, threshing efficiency, separating and cleaning in terms of separation efficiency, separation loss, cleaning efficiency, cleaning loss and fuel consumption based on drum speed and feed rate.

A tachometer was used to determine the peripheral speed of the cylinder, while a stopwatch was used for elapsed time measurements and an electronic balance of sensitivity of 0.01 kilograms was used in weight measurements during the performance evaluation of the machine. For measuring the fuel consumption of the engine, a graduated cylinder was used to measure the fuel consumed that was refilled during the test. The locally available variety of teff (white teff) commonly called "manya" in Ethiopia was used for the evaluation.

The performance study was undertaken at different threshing drum speeds and feed rates of the machine. Thus, different parameters like threshing capacity, threshing efficiency, cleaning efficiency grain loss, and fuel consumption were measured to assess the suitability of the threshing machine.

The thresher was evaluated at three levels of cylinder speed of 800, 1000, and 1200 revolutions per minute by using the tachometer. The ranges were selected based on the speed required to cause the threshing of the crop without unnecessary overrunning of the thresher. It was also assumed that running the thresher at a speed below 800 rpm would not achieve effective threshing of the crop and running it at a speed above 1000 rpm may only cause wastage of energy without a corresponding increase in threshing efficiency.

The feed rate of the developed thresher was determined by measuring out 6, 8, and 10 kilograms of un-threshed teff. These masses of the un-threshed crop were measured using a spring balance. The times to feed in the various masses of the teff were measured and each was converted into kilograms per minute. The feed rates of 6, 8, and 10 kg/min were therefore used for the evaluation of the thresher. These feed rates were selected based on the mass of the un-threshed crop that an operator can manually feed into the thresher through the chute per unit of time.

The threshing efficiency was used to determine how effectively the thresher was in carrying out its primary function of threshing the teff. The cleaning efficiency was used for the evaluation of the ability of the thresher to clean the crop effectively. In addition, the throughput capacity was used to evaluate how fast the thresher could perform its given task of threshing and cleaning. Lastly, the amounts of grain loss by the thresher were considered to assess the machine's overall performances, in extensive and intensive methods. For measurements of the main performance parameters, the testing principles of FAO (2007) were used as follows:

Threshing Efficiency (TE)

Threshing efficiency (TE) is defined as the percentage ratio of the threshed grain to the total quantity of sample grain after a threshing process.

$$TE=100-(Q_U/Q_T)\times 100 \quad (1)$$

Where: TE = threshing efficiency in percentage,

Q_U = un-threshed quantity of grains in a sample in kg, and Q_T = the total quantity of grains (kg) threshed and un-threshed in the sample

Cleaning Efficiency (CE)

Cleaning efficiency (CE) is the ratio by weight of the grains collected at the grain outlet to the total weight of the chaff and grains collected at the same outlet expressed as a percentage (Kepner, et al.1987).

$$C_E=(W_t-W_c)/W_t\times 100 \quad (2)$$

Where: - C_E = Cleaning efficiency in percent

W_t = total weight at the outlet in kilograms and

W_c= chaff weight at the outlet in kilogram.

Throughput Capacity (TC)

The machine throughput capacity is the amount of the actual cleaned grain that a machine is able to thresh per a given time.

$$T_C=(Q_s/T)\times 60 \quad (3)$$

Where: T_C = Throughput capacity expressed in kilogram per hour (kg hr^{-1})

Q_S = quantity of grains collected at the grain outlet in kilogram and T = time taken to thresh in minutes.

Non collectable grain losses

The non-collectable grain loss of the machine is the sum of drum loss and separation loss.

$$D_L(\%)=(\text{Weight of unthreshed grain (kg)})/(\text{Total grain weight (kg)})\times 100 \quad (4)$$

$$S_L(\%)=(\text{Weight of grain goes withdust (kg)})/(\text{Total grain weight (kg)})\times 100 \quad (5)$$

Where:

DL = drum loss

SL = separation loss

The fuel tank was flled to full capacity before and after the test. Amount of refueling after the test was the fuel consumption for the test. While flling up the tank, careful attention was taken to keep the tank horizontal and not to leave empty space in the tank.

$F_c = F_r / t$ (6)

Where, Fc = fuel consumption (l /hr)

Fr = re-flled quantity of fuel (1)

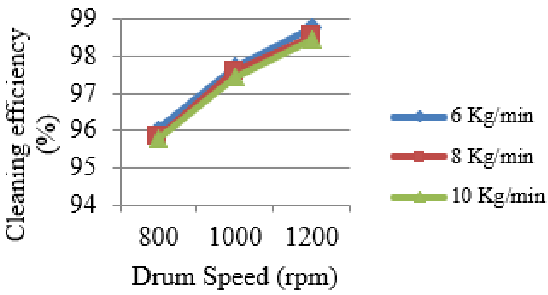
t=seeding time (hr).

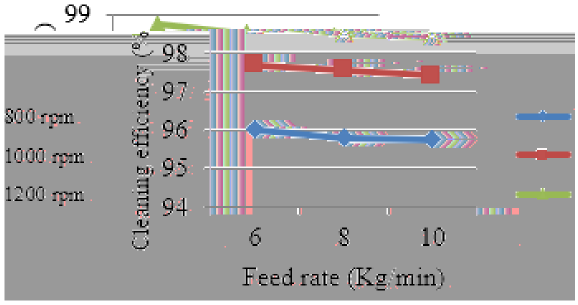
The performance tests of teff threshing were conducted at three levels of drum speed, three levels of crop feed rate, and three replications by using a completely randomized design (CRD) of a 3x3x3 factorial experiment with three replications in each treatment and comparison between treatment means by least signifcance difference (LSD) at 5 percent level. The drum speeds of 800, 1000, and 1200 rpm were considered for the experiment and were attained with the help of the fuel-controlling throttle valve. Three levels of feed rates 6, 8, and 10 kg/min were considered for the experiment and were attained by varying the time of feeding the crop in the threshing drum. The Three levels of drum speeds and three levels of feed rates were taken as independent variables. The effect of both independent parameters on non-collectible grain losses, cleaning effciency, threshing effciency, and threshing capacity was studied.

Efficiency

Table 1 shows the effect of threshing drum speed, crop feed rate, and the combined effect of drum speed and feed rate on the mean percent of cleaning effciency Similarly, Figure 1 shows the relation between drum speed and feed rate on mean cleaning effciency. The analysis of variance (ANOVA) revealed that the threshing drum speed had a signifcant effect ($p < 0.05$) on cleaning effciency, whereas crop feed rate and interaction of drum speed and feed rate had no signifcant effect ($p > 0.05$) on cleaning effciency. The combined effect of drum speed and crop feed rate had a signifcant effect on the percentage of cleaning effciency. Nonetheless, as can be seen from Table 1, the effect was dominantly due to variations in drum speeds rather than crop feed rate.

Figure 1 show that cleaning effciency has a direct





Effect of drum speed and feed rate on cleaning effciency

Effects of threshing drum speed, feed rate and their interaction on cleaning effciency

		95.868^{c}	97.569^{b}	98.576^{a}	0.348
Cleaning effciency (%)		97.496^{a}	97.309^{a}	97.208^{a}	0.348
	Ds_1	96.020^{c}	95.817^{c}	95.767^{c}	0.6027
	Ds_2	97.703^{b}	97.580^{b}	97.423^{b}	
	Ds_3	98.763^{a}	98.530^{a}	98.433^{a}	

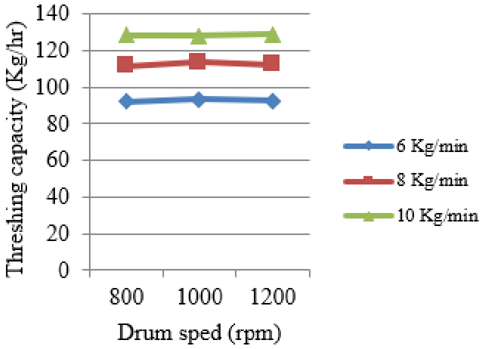
Means followed by the same letter (or letters) do not have a significant difference at a 5% level of probability

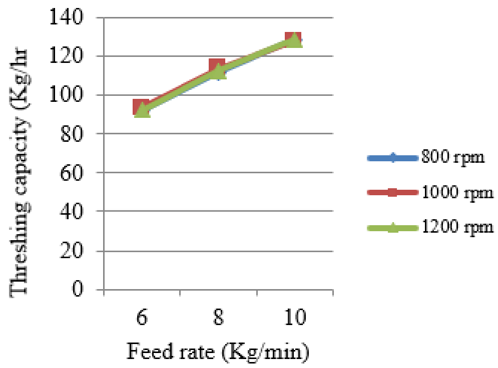
relationship with drum speed, i.e. with the increase in the drum speed the cleaning effciency increased, and it decreased with the increase in feed rate. The cleaning effciency increased with the increase in drum speed as the threshing cylinder and cleaning system were mounted on the same shaft. Hence, an increase in the speed of the threshing drum increased the material other than grain separation. On the other hand, cleaning effciency decreased with the increase in feed rate, as at higher feed rates, frequent choking occurred. The inverse relationship between cleaning efficiency and feed rate was indicated due to the increased load on the sieve that restricted the free movement of grains and undesired materials

Efficiency

The effect of drum speed and feed rate and the interaction of drum speed and feed rate were non-significant and in all cases 100 percent. This happens due to straw outlet augers which have rubbing action. In general, the average threshing efficiency of the machine was 100 percent.

The ANOVA revealed that the crop feed rate had a significant effect ($p < 0.05$) on threshing capacity. Whereas threshing drum speed and the interaction of drum speed and feed rate had no significant effect ($p > 0.05$) on threshing capacity. From Table 2 it can be seen that the combined effect of drum speed and crop feed rate had a significant effect on mean values of threshing capacity. However, the effect was dominantly due to variations in crop feeding rate than drum speeds. Threshing capacity





Effect of drum speed and feed rate on Threshing capacity

Effects of threshing drum speed, feed rate and their interaction on threshing capacity

		110.92^{a}	111.74^{a}	111.30^{a}	1.371
Threshing capacity (Kg/hr)					1.371
		92.79^{c}	112.69^{C}	128.48^{a}	
	Ds_1	92.38^{c}	111.77^{b}	128.60^{a}	2.375
	Ds_2	93.48^{c}	113.73^{b}	128.00^{a}	
	Ds_3	92.50^{c}	112.57^{b}	128.83^{a}	

Means followed by the same letter (or letters) do not have a significant difference at a 5% level of probability

varied with crop feed rate but had an insignificant variation with drum speed. The grain straw ratio of the crop affects the threshing capacity of the machine, which was at the ratio of 1:3.2 in this experiment

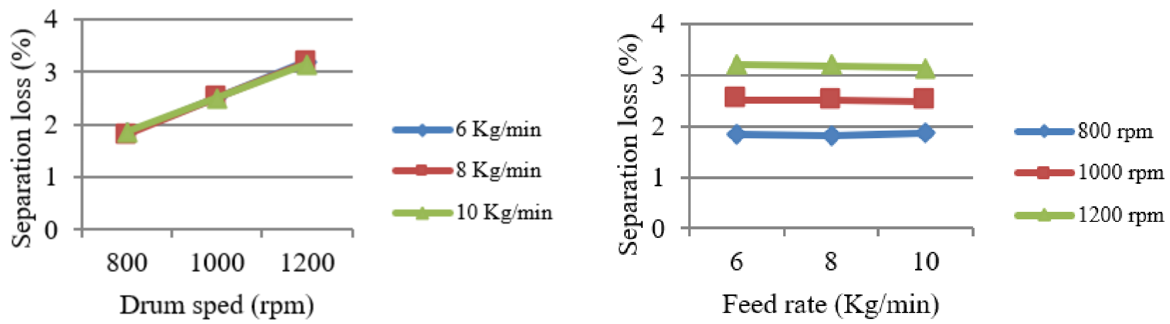
Grain separation losses are those losses that cannot be collected from chaff outlets and aspirators. ANOVA revealed that the threshing drum speed had a significant effect ($p < 0.05$) on grain separation loss, whereas crop feed rate and interaction of drum speed and feed rate had no significant effect ($p > 0.05$) on separation loss. From Table 3 it can be seen that the crop feeding rate hasn't any significant effect on grain separation loss. The combined effect of drum speed and crop feed rate had a significant effect on the percentage of grain separation loss. However, the effect was dominantly due to variations in drum speeds than crop feed rate. Thus, the factor means clearly indicate that grain separation losses were directly related to the drum speed, i.e. with the increase in drum speed, the grain separation losses also increased, while these were inversely proportional to crop feed rate i.e. with an increase in crop feed rate, the grain separation losses decreased (figure 3).

The minimum grain separation loss (1.807 percent) was obtained at a drum speed of 800 rpm and feed rate of 8 Kg/min., whereas the maximum separation loss was recorded (3.203 percent) at a drum speed of 1200 rpm and feed rate of 6 Kg/min. The reason for grain separation losses increasing with an increase in drum speed is due to the mounting of both the drum and aspirator on the same shaft and thus, leading to higher non-collectable losses. Studies conducted by FAO (2018) on food loss analysis of causes and solutions of teff supply chain in Ethiopia, showed that threshing with the aid of animals trampling on the grains leads to losses of 7.7 %, which is higher than the losses obtained in this study

Effects of threshing drum speed, feed rate, and their interaction on grain separation loss

		1.841^{c}	2.514^{b}	3.178^{a}	0.0967
Separation loss (%)					0.0967
		2.523^{a}	2.502^{a}	2.508^{a}	
					0.1674
	Ds_1	1.847^{c}	1.807^{c}	1.870^{c}	
	Ds_2	2.520^{b}	2.517^{b}	2.507^{b}	
	Ds_3	3.203^{a}	3.183^{a}	3.147^{a}	

Means followed by the same letter (or letters) do not have a significant difference at a 5% level of probability.



Effect of drum speed and feed rate on grain separation losses

The effects of drum speed and feed rate on dependent variables were grain separation losses, cleaning efficiency, and threshing efficiency. To obtain the optimum combination of parameters the criteria adopted were that the threshing efficiency should be the maximum, the percent of grain separation losses should be minimum, and the cleaning efficiency should be the maximum. The threshing efficiency was 100 percent for all treatment combinations; therefore any combination could be selected. Grain separation loss was less than 2 percent for drum speed 800rpm for all feeding rates. Therefore, any combination of these would lead to optimum performance. Amongst combinations selected based on the percent of grain separation losses, the separation loss was the minimum at a drum speed of 800rpm and crop feed rate of 8 Kg/min (1.807%).

The performance evaluation of the imported CAAMS teff thresher was carried out and from the result, it shows that the thresher has a great potential in mechanizing the threshing process of teff. Data from this study led to the following conclusions:-

The optimum threshing efficiency of 100 % was obtained for all combinations while threshing capacity and cleaning efficiency were obtained at 1200 rpm drum speed and

Strengthening the teff value chain in Ethiopia. Retrieved from ATA.GOV website http://www.ata.gov.et/wpcontent/uploads/Tef Diagnostic-Report.pdf.

ENS (Ethiopian Nutrition Survey). (1959). A Report by Interdepartmental Committee on Nutrition for National Defense. ENS, Addis Ababa.

FAO (2007). Agricultural Engineering in Development Post-Harvest Operations. (Threshing and Shelling). http://www.fao.org/docep/19/1/07. Pp23.

FAO. (2018). Food loss analysis: causes and solutions - Case study on the teff value chain in the Federal Democratic Republic of Ethiopia. Rome. 48 pp. Licence: CC BY-NC-SA 3.0 IGO.

Kepner, R.A., Bainer. R & Barger, E.L.(1987). Principles of Farm Machinery. 3rd Edition. The AVI Publishing Company, Inc., USA.

Manfred, H. 1993. Harvest index versus grain/straw-ratio. Theoretical comments and experimental results on the comparison of variation. *Euphotic, 68*(1), 27-32.

Melese L., Tariku S. & Selamawit, M. (2017). Evaluation of improved Tef (Eragrostistef L.)Varieties in konso area, Southern Ethiopia. *International Journal of Research in Agriculture and Forestry, 4*(11), 32-34,

Seyfu, K., (1997). Teff. Eragrostistef (Zucc.) Trotter. Promoting the conservation and use of underutilized crops". Rome: Institute Plant. *Genetics and Crop Research. 12,* 35.

Taddesse, E. (1969). Teff (Eragrostistef): The cultivation, usage and some of the known diseases and insect pests, Part1. Debre Zeit Agricultural Experiment Station Bulletin No. 60.Alemaya University of Agriculture, Dire Dawa, Ethiopia

Witney, B., (1988). Choosing and using farm machines. Longman