International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.9., Issue.3, 2021
May-June

RESEARCH ARTICLE

ISSN: 2321-7758

EVALUATION OF FARC MULTI-ACTION THRESHER FOR FINGER MILLET THRESHING

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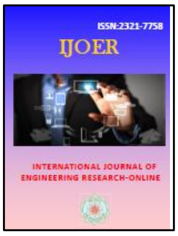
DOI: 10.33329/ijoer.9.3.15



ABSTRACT

Finger millet is a cereal crop grown in most parts of Ethiopia, used for food, in different forms and as an input in preparing tradional alcoholic drinks in some areas. The traditional methods of finger millet threshing are the only method available in most parts of the country, including the major producer western part of Oromia. Hence, this activity is aimed to evaluate an engine powered smaller crops and spice Grains multi-action thresher for finger millet threshing then determine baseline data for modification/development of thresher for the crop. The experimental was conducted in a split- plot design having drum speeds (V1 = 600rpm, V2= 700rpm and V3 = 800rpm) in main plots and concave clearance (20 and 25mm) in sub-plots with three replications as block. The maximum threshing capacity of 82.74 kg/hr was recorded at combination effect 800 rpm and 27 mm drum speed and concave clearance respectively. At this optimum threshing capacity, cleaning efficiency, percentage of loss and threshing efficiency is 48.81, 7.14 and 93.81% respectively. Based on the results obtained, regarding to performance indices like low threshing capacity and cleaning efficiency and to reduce percentage of loss, it is recommended that machine requires a modification.

Key words: Evaluation, finger millet, threshing

Background and Justification

Finger millet (*Eleusine coracana (L.) Gaertn. ssp. coracana),* is an important crop grown inlow input farming systems in western and south western Ethiopia (MA Mgonja, et al.,2007). Finger millet is a highly tillering annual crop, whose average height can reach as high as 1.0 m, but 1.6 m Tillers come from the base of the plant and axillary buds along the stem. Each tiller produces a panicle. Leaves are generally 30 to 40 cm long, but can reach 70 cm and are narrow (1.5 to 3 cm) (Silas T.A.R. Kajuna, 2001). Panicle branches commonly come from the same place giving a finger like appearance. The number of branches ranges from 4 to 19; they can be straight (3 to 10 cm long) or they can be curved like a hand with fingers partially closed (hence the name finger millet). Seeds are formed in florets generally arranged in two rows along the panicle branch. The seeds are generally dark brown, red brown or purple, although light brown and cream colored seeds are found. Seeds are hard and very small, up to 2 mm in diameter (Cristina Apetrei, 2012).

Finger millet is a cereal crop grown in some parts of Ethiopia, used for food, as porridge and meal food, besides its importance as a staple food crop, finger millet contributes greatly to the incomes of rural households, particularly women. It is brewed into local beer for sale or is sold directly as grain in local markets where there is ready demand. In Ethiopia, it is grown on approximately 456,057.31 ha, with yield 22.60 Qt/Ha (CSA, 2018).

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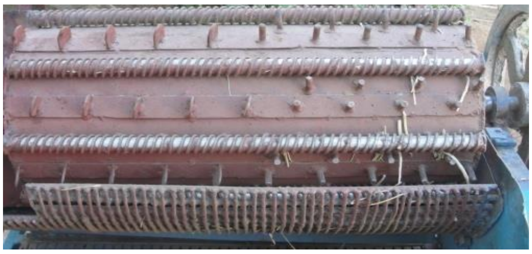
Finger millet threshing is the most difficult in post harvest threshing activity like some cultivars of east African enclosed head sorghums, mainly due to their nature of the grain firm attachment to florets and to its glumes in the latter (Mary Tamale, 2001, MA Mgonja, et al.,2007). It is done manually by women and men by beating its heads with sticks or clubs repeatedly until almost all the grains are detached from the heads on a mat, canvas or bare ground and animal trampling. In order to ease grain collection after beating, sometimes the heads of millets may be stuffed in to bags, prior to beating. The straw that remains after threshing may be used as a source of fuel or used as mulch as well as animal feed. However, on the outset the level of mechanization in finger millet farming systems is almost negligible in east African countries; no one knows how farmers are trying to cope with labor drudgery (Ambitsi N, 2011*).* Thus, as the traditional methods of finger millet threshing is the only method available in most parts of the country, including the major producer area, the western oromia. The long hours of day labour of these "human threshers" is not anything to write home about as an average woman can only thresh about 10 kg per day (www.fao.org/docrep). Thus, the traditional methods are arduous and slow.

So that, availing the necessary mechanical threshing is a means to overcome the problems and searching for machines that can thresh the finger millet is mandatory priority of the solution. Additionally, the finger millet threshing machinery data is not also available in the country, so that, searching for thresher that might be developed for another crops of closely resembles the physical characteristics of finger millets grains which is enclosed within the florets is an option.

Accordingly, the center (BAERC) search and select FARC engine operated Multi-thresher for smaller crops and spice Grains. In addition to the sorghum, the machine was evaluated for threshing of Black-cumin, Linseed & Niger seed. The result analysis of its output for some crops with similar threshing characteristics is reported in 2013 by the center as; 100% threshing and cleaning efficiency with no grain breakage for muira and fandisha sorghum threshing, with less than 1% seed in glumes at optimum speed 600rpm and 650kg/h feed rate. In Black cumin, threshing and cleaning efficiency are 100% (but with inclusion of sieve), with no grain breakage and less than 1% seed in pods and its output 400-500kg/h.

The machine is combined threshing systems of beating, rubbing and chopping with specially designed beater chopper with spiral bar and axial flow system. Since, the machine has with the above performances results of crops of finger millet type threshing characteristics might be suitable for the finger millet threshing. Hence, this activity is aimed to evaluate the engine powered smaller crops and spice Grains multi-thresher for finger millet threshing then determine baseline data for modification/development of thresher for the crop.



Picture1. Traditional threshing (left) and threshing parts of FARC thresher (right)

Materials and Methods

A prototype production, according to FARC motorized small crops and spice Grains Multi-thresher, and its evaluation were done at Bako Agricultural Engineering Research Center (BAERC), which is located in West Shoa zone of Oromia National Regional State, Ethiopia.

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Descriptions of the Machine

The machine consisted mainly a frame, threshing drum, blower, concave and feeding table. The threshing drum was fixed with short peg-tooths followed by blades from inlet to out let and rod coiled on water pipe. The concave was made of mild steel rods with spacing of 6 mm. The concave clearance between the threshing drum and concave was adjustable. The power from a diesel engine (10hp) was transmitted to the threshing drum by V-belts.

Figure 2. A prototype and its basic parts

Performance Evaluation of the prototype

Three levels of engine crank shaft speed and two levels of concave clearance were used to evaluate the performance of the machine. The performance of the machine was evaluated in terms of threshing capacity (kg/h), threshing efficiency (%), cleaning efficiency (%) and percentage of loss (%) using the following equations; Ndirika (1994) and Gbabo *et al.,* (2013).

Threshing capacity (kg/h) = $\frac{Q_t}{T_m}$

Threshing efficiency (%) = $\frac{Q_t}{Q_t + Q_{ut}} X100$

Cleaning efficiency (%) = $\frac{Qt}{Q_{t+cf}} \times 100$

Percentage of loss (%) = $\frac{Q_{ut} + Q_{tch}}{Q_t + Q_{ut} + Q_{tch}} X100$

Where:Qt – Mass of threshed grain at grain outlet (kg); Tm – time of threshing operation (h); Qut – quantity of unthreshed grain(kg); Qt+cf - quantity of threshed grain and chaff at grain outlet (kg), W_{hw} – quantity of winnowed husk (kg); Qtch – quantity of threshed grain in chaff (kg)

Experimental Design

The experimental was conducted in a split-plot design having drum speeds in main plots, concave clearance in sub-plots with three replications as block.

- The details of the treatments were: three levels of drum speeds were used by adjusting fuel control throttle valves of the engine (V1 = 600rpm, V2= 700rpm and V3 = 800rpm), Akintayo A. , 2015 and two levels of concave clearance C1 = 20mm and C2 = 25mm
- Full feeding rate (the batch that can full the inlet area) that make the farmer easy while using the machine and 7% measured mean grain moisture content that is close to the recommended to be threshed (Akintayo A. , 2015) were used

Statically Analysis

Data were subjected to analysis of variance using statically procedure as described by Gomez and Gomez (1984). Analysis was made using Gen Stat 15th edition statistical software.

Result and Discussion

Performance of the prototype machine was evaluated interims of the following parameters and discussed below.

Threshing capacity (Kg/hr)

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Table 1. Effect of drum speed and concave clearance on threshing capacity

Source of Variation							
Combination Effect of (VXC)			***Main Effect***				
Velocity (rpm)	Con. Clearance (mm)		Velocity (rpm)	Mean	Clear.(mm)	Mean	Grand mean
	20	25					
600	57.18	58.72	600	57.78	20	65.04	
700	66.67	67.75	700	67.21	25	69.61	
800	71.27	82.74	800	76.99			67.32
SE (M)	1.181		0.835		0.682		
LSD (5%)	3.280		2.319		1.893		
CV (%)	2.1						

The maximum threshing capacity of 82.74 kg/hr was recorded at combination effect 800 rpm and 27 mm drum speed and concave clearance respectively. It has direct relationship with drum speed and concave clearance, Gbabo *et al*., (2011) reported that throughput capacity would increase with an increase in the operating speed of a thresher. The machine threshing capacity is low due to the intake, chopping and threshing unit problems. Akintayo A., 2015, reported that throughput of 46.7 kg hr-1 was obtained at 9.7 % moisture content , 300rp cylinder speed and 5mm concave clearance.

Cleaning Efficiency (%)

Table 2. Effect of drum speed and concave clearance on cleaning efficiency

Source of Variation							
Combination Effect of (VXC)			***Main Effect***				
Velocity (rpm)	Con. Clearance (mm)		Velocity (rpm)	Mean	Clear. (mm)	Mean	Grand mean
	20	25					
600	46.57	45.56	600	46.06	20	50.20	
700	53.15	45.94	700	49.54	25	46.77	
800	50.87	48.81	800	49.84			48.48
SE (M)	1.391		0.983		0.803		
LSD (5%)	3.861		2.730		2.29		
CV (%)	3.5						

The maximum cleaning efficiency of 53.15% was recorded at combination effect 700rpm and 20mm drum speed and concave clearance respectively, while the minimum was obtained at 600rpm and 25mm drum speed and concave clearance. Even though, the cleaning efficiency of the machine is poor and requires modification Ndirika (1994) plotted a similar graph where cleaning efficiency of millet increased with cylinder speed. Abarchi (2011) got a straight line graph when he plotted cleaning efficiency against speed of revolution of millet thresher and Abolaji (1980) result for a similar plot was not different from these results.

Percentage of loss (%)

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Table3. Effec t of drum speed and concave clearance on percentage of loss

Source of Variation							
Combination Effect of (VXC)			***Main Effect***				
Velocity (rpm)	Con. Clearance (mm)		Velocity (rpm)	Mean	Clear.(mm)	Mean	Grand mean
	20	25					
600	5.54	7.99	600	6.77	20	5.36	
700	6.02	8.77	700	7.39	25	7.97	
800	4.53	7.14	800	5.84			6.67
SE (M)	0.149		0.105		0.086		
LSD (5%)	0.413		0.292		0.238		
CV (%)	2.7						

The maximum percentage losses of 8.77% was recorded at combination effect 700rpm and 25mm drum speed and concave clearance respectively, while the minimum 4.53% was obtained at 800rpm and 20mm drum speed and concave clearance. The loss is due to unthreshed head and grain with chaff.

Study on millet threshing carried out by Kamble et al., (2003) gave the obtained highest threshing efficiency as 98.6 % and 2.1 % total grain loss

Threshing efficiency (%)

Table 4. Effect of drum speed and concave clearance on threshing efficiency

Source of Variation							
Combination Effect of (VXC)			***Main Effect***				
Velocity (rpm)	Con. Clearance (mm)		Velocity (rpm)	Mean	Clear.(mm)	Mean	Grand mean
	20	25					
600	96.28	94.97	600	95.94	20	95.94	
700	94.94	92.34	700	93.64	25	93.71	
800	96.62	93.82	800	95.22			94.83
SE (M)	0.299		0.211		0.173		
LSD (5%)	0.830		0.587		0.479		
CV (%)	0.4						

The maximum threshing efficiency of 96.62% was recorded at combination effect 800rpm and 20mm drum speed and concave clearance respectively, while the minimum was obtained at 700rpm and 25mm drum speed and concave clearance. Akintayo A., 2015, reported that threshing efficiency at 7.8 % moisture content increased from 94.7 % at 60 kg hr-1 feed rate to 95.6 % at 150 kg hr-1. Generally, threshing efficiency increase with increasing drum speed.Ndirika (1994), Abolaji (1980) and Abarchi (2011) plotted and got a similar trend where the threshing efficiency of threshed millet increased with cylinder speed.

Conclusion and recommendations

Finger millet has been threshing, in Ethiopia at present, is done manually by women and men by beating its heads with sticks or clubs repeatedly until almost all the grains are detached from the heads on a mat, canvas or bare ground and animal trampling. The long hours of day labour of these "human threshers" is not anything to write home about as an average woman can only thresh about 10 kg per day (www.fao.org/docrep).

In an effort to alleviate some of the problems associated with primary processing of finger millet, based on closely resembles physical characteristics of finger millets grains , motorized FARC small crops and spice grains multi thresher was selected and evaluated**.** Based on the results obtained, regarding to performance indices like low threshing capacity and cleaning efficiency and to reduce percentage of loss machine requires a modification.

Recommendations

Although, the physical properties of finger millet is similar to small crops and spice grains, finger millet should be threshed by more impact/biting load rather than rubbing because of its tillers are long and much number of tillers like teff. However, FARC small crops and spice grains multi thresher has few and short active part that apply the impact loads to thresh it. Additionally, at feeding area the drum has not blades that create active/rapid feeding mechanism. Because of these reasons, the threshing capacity of the machine was low.

Therefore, the drum should be wire loop in order to replace short pegs on it and then blades to have many impact loaders and more contact threshing part. This is to give room for the feeding of the thresher at greater rates than those used in the evaluation of the thresher. The machine also has no mechanical and efficient aerodynamic cleaning unit for this crop, poor cleaning efficiency is happened. So, the cleaning unit should be worked to improving the cleaning efficiency already achieved on the thresher.

Acknowledgements

I would like to thank all Bako Agricultural Engineering Research Center (BAERC) employees who supported me during the fabrication of the prototype machine and collection of data with all the necessary inputs. I would also like to thank my sponsor, Oromia Agricultural Research Institute for the provision of research fund.

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