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Evaluation and Selection of Existing Machines for Sorghum Threshing

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ABSTRACT: Sorghum threshing in Ethiopia is characterized by high grain breakages and grain loss. Existing threshing methods are time-consuming and yield a low throughput. To reduce the losses, optimal levels of machine and operational parameters influencing threshing need to be established. The performance of the existing three crop threshersmachine namely Fadis Sorghum thresher, Jimma Replaceable Drum Multi-Crop thresher, and Jimma multi Rice thresher was evaluated in terms of threshing capacity, threshing efficiency,cleaning efficiency, andbreakage for sorghum crop. The maximum threshing capacity was observed from Jimmarice thresher which is 679.12 Kg/hr obtained at 8kg/min feed rate and 800 rpm, maximum cleaning efficiency was observed from Jimma rice thresher which is 96.80% atoccurred at 6kg/min feed rate and 700 rpm, maximum threshing efficiency was observed from Jimma rice thresher which is 100.00% obtained at 4kg/min feed rate and 800 rpm,and also from Jimma replaceable drum multi-crop thresher threshing efficiencywas observed 100.00% obtained at 4kg/min and 700rpm and broken(damaged) grain was 4,81% fromJimma rice thresher at 800 rpm and 4kg/min feed rate. According to the results obtainedJimma rice thresher was better than others in threshing capacity, threshing efficiency, and cleaning efficiency.

KEYWORDS: threshing, sorghum, capacity, efficiency

I. INTRODUCTION

Sorghum (Sorghum bicolor L. Moench) is a cereal crop utilized as human food with the potential of providing food security in arid and semi-arid lands where many cereal crops produce little yield [4]. Sorghum grows in areas of altitude 500 meters - 1700 meters above sea level (m a.s.l.), with an annual rainfall of 300mm. Sorghum can replace maize (Zea mays L.) as a staple food in case of crop failure as it is closely related to maize in utilization hence an alternative crop in marginal areas [7].Sorghum is used as human food as well as animal feed and industrial raw material [4].

In southwestern Oromia, there is a high production area that did not give attention to minimize postharvest losses. In the 2008/2009 production season the total harvested sorghum was about 1243974.5Qt, 851781.48Qt, and 522038Qt in Jimma, Buno Bedele, and Iluababor zones respectively as the zones agricultural office said. After the crop is harvested, it undergoes several operations that, if improperly done, may result in serious losses. The average post-harvest losses of food crops such as teff, sorghum, wheat, and maize are 12.9 percent, 14.8 percent, 13.6 percent, and 10.9 percent respectively [2].

The threshing methods can be divided into artificial threshing, animal threshing, and mechanical threshing. Along with the rise of mechanization, more and more farmers use mechanical threshing machines in the world. In rural Africa, threshing involves beating the dried sorghum panicles with sticks on the ground or in sacks, or using a mortar and pestle. Grain is separated from dirt and chaff by winnowing. The time required for threshing depends on variety, the degree of dryness of the grain, and the method of threshing. Thresh early to reduce field exposure to birds, rats, etc. (ensure that the moisture content is low enough); The majority of farmers thresh their seed from panicles by beating with sticks or rubbing the panicle on a hard surface like a rough stone or storing it on panicles. This contributed to high mechanical damage due to the breaking of seeds into small pieces hence reducing the seed quality [2].When seeds within a seed lot are broken into pieces, the embryos are damaged hence reducing the germination capacity of the seeds. There were some threshing machines designed at different research centers such as Fadis, Melkasa, and Jimma research centers. the Fadis made sorghum threshing machine was tested at the constant grain moisture content of 20-21%, and the test result indicated that the threshing efficiency, output capacity, and cleaning efficiency were found to be 88.97-97.08%, 7-12 qt/h and55%-78%respectively where the Jimma drum replaceable multi crop threshing machine was tested at moisture content 9.8% and the result indicated that the threshing efficiency, output capacity, and cleaning efficiency were 98.63%, 780.68 kg/hr and 98.56% respectively. Therefore, to increase production and to minimizing thelosses, the use of appropriate technology should be important because the threshed either by hand or by animal feet yet. Hence, the objective of this activity was to evaluate and selected the best performed sorghum threshing machine

II. MATERIALS & METHODS:

Experimental site

The experiment was conductedat Jimma zone of Madara kebele of Gomma woreda

Materials & sources required

The materials required for this study was:

- ✓ Fadis type sorghum thresher,
- ✓ Jimma drum-beater replaceable multi crop thresher
- ✓ Jimma made rice thresher
- ✓ stopwatch -for recording time of operating
- ✓ small size digital balance-for measuring output and broken grain
- ✓ digital tachometer –for measuring the speed of the machine
- ✓ oven-dry machine for measuring moisture content

Fig.1. a. Jimma Replaceable Drum Multi Crop Thresher b. Jimma Rice Thresher

Fig.2. Fadis Sorghum thresher

Methods

The experiment was conducted in factorialwith RCBD design with three feed rate, three drum speed and three replication for the three threshers.

Collected data:

The data was collected during performance testing before testing, during testing, and after testing. The data collecting from field testing and laboratory testing based on the measurement or test required. The data collected from laboratory and field test were:

Crop parameters

- ➢ Moisture content
- ➢ Grain –straw ratio

Machine performance

- ➢ Threshing capacity
- ➢ threshing efficiency
- ➢ cleaning efficiency

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- mechanical grain damage
- **Moisture Content**

The moisture content of sorghum grain was determined using a drying oven. The grain samples were dried at 130°C for 18 hours [1]. the weight loss of the samples was recorded and the moisture content was determined in percentage.

The moisture content on wet basis, %:-

$$mc = \frac{weight\ of\ wet\ sample - weight\ of\ dry\ sample}{weight\ of\ dry\ sample}$$

- **Grain –straw ratio**

From the sorghum which was threshed, 3 samples are randomly taken of approximately 0.5kg each. The samples was placed in sealed plastic containers and taken to the laboratory where the grains and straw were separated by hand. The straw and grains from each sample were kept paired. After weighing, the samples were oven-dried at 130°C for at least 15 hours and then reweighed [5].

The moisture content (M) on dry basis, %:

$$mc = \frac{weight\ of\ wet\ sample - weight\ of\ dry\ sample}{weight\ of\ dry\ sample}$$

The Grain-Straw ratio (K) was calculated as follows:-

$$k = \frac{weight\ of\ dry\ grain}{weight\ of\ dry\ straw}$$

Determination of machine Performance Parameters

The performance tests of thesorghum threshing machines were conducted at different three threshers, at different levels of cylinder speed and three levels of feeding rates by using factorial with RCBD design of a 3x3x3 factorial experiment with three replications in each treatment and comparison between treatment means by least significance difference (LSD) at 5% level for locally available varieties separately. From the analysis of samples and sampling time, feed rate, threshing recovery, threshing efficiency, cleaning efficiency of main grain, outlet rate of damaged grains, loss of grain was calculated as follows.

- **Threshing capacity**

The threshing capacity was used to evaluate for how fast the thresher machine can perform its given task of threshing.It is the amount of the actual cleaned grain that a machine is able to thresh per time and it was determined using the relationship as determined by [6] and [4].

$$\mathbf{Tc} = \frac{\mathbf{Q_s}}{\mathbf{T}}$$

Where: TC = threshing capacity expressed in kilogram per minute (kg /h)

QS =quantity of grains collect at the grain outlet in kilogram and

T = time taken to thresh in minutes

- **Threshing efficiency**

Threshing efficiency was used to determine how effectively the thresher was in carrying out its primary function of threshing the crop. It is defined as the percentage ratio of the threshed grain to the total quantity of sample grain after the threshing process. The threshing efficiency was determined using the relationship as determined by [6] and [4]

$$\mathbf{TE = 100 - \frac{Q_u}{Q_T} \times 100}$$

Where: TE= threshing efficiency in percentage

QU =unthreshed quantity of grains in a sample in kg

QT = the total quantity of grains (kg) threshed and unthreshed in theSample

Cleaning efficiency

The cleaning efficiency was used for the evaluation of the ability of the thresher to clean the crop effectively. The cleaning efficiency is the ratio by weight of the grains collect at the grain outlet to the total weight of the chaff and grains collect at the same outlet expressed as a percentage. The cleaning efficiency was determined using the relationship as determined by [6] and [3].

$$\mathbf{C_E = \frac{(W_{t-}W_c)}{W_t} \times 100}$$

Where:

CE = Cleaning efficiency in percent

Wt = total weight at the outlet in kilogram and

WC= chaff weight at the outlet in a kilogram.

- **Mechanical grain damage**

Mechanical damage was used to determine the quantity of visible physical damage to grains that can be owed to the thresher. The mechanical grain damage was the expression as outlined by [6] and [4]. $\mathbf{MD = \frac{Q_b}{Q_t} \times 100}$

Where:

MD = Mechanical grain damage (in percent),

Qb= the number of damage grains in kilogram, and

Qt = total weight of grains in the sample (kg).

Data analysis

The collecting data was analyzed using a factor design with the RCBD method. The treatments under study were tested at three selecting feeding rates (4kg/min, 6kg/min, 8kg/min), three cylinder speeds (600rpm, 700rpm, 800rpm), and three threshers were applied at three replications and analysis by statistix 8software.

III. RESULT AND DISCUSSION

Threshing capacity: The performance of the three machines (Fadis sorghum thresher (FST), Jimmareplaceable Drum multithresher (JRDMCT), and Jimma rice thresher (JRT)) was evaluated at various drum speed and feed rate at average moisture content of 18.3% and grain-straw ratio of 1:63sorghum grain in terms of threshing capacity, threshing efficiency, cleaning efficiency, percentage of grain damaged.

Feed rate x speed				Speed (rpm)	Mean	Feed kg/hr	Mean	Type	Mean
	Speed(rpm)								
Feed rate (kg/min)	**600**	**700**	**800**	**600**	499.53[a]	**4**	508.02[b]	**FST**	394.12[c]
4	420.99[d]	492.79[cd]	610.27[a]	**700**	555.76[b]	**6**	545.82[b]	**JRDMCT**	590.26[b]
6	495.23[bcd]	567.67[ab]	574.60[abc]	**800**	608.22[a]	**8**	609.66[a]	**JRC**	**679.12[a]**
8	582.37[ab]	606.84[a]	639.78[a]						
SE			44.11		25.46		25.46		25.46
LSD			0.1966		0.0003		0.0007		
CV									16.88

The result indicated that the maximum threshing capacity was **679.12 kg/hr**, which is observed from Jimma rice thresher (JRC) as shown in the figure above. The mean capacity of the three threshers is significantly different,but this threshing capacity was not significantly different among feed rate and speed means.

Threshing Efficiency
The maximum threshing efficiency of the machine was about 100.00% which is observed from Jimma rice thresher (JRC) and Jimma replaceable Drum multi thresher (JRDMCT). This threshing efficiency was not significantly different among feed rate, speed means, and types of the thresher**.**

Feed rate x speed				Speed (rpm)	Mean	Feed kg/hr	Mean	Type	Mean
	Speed(rpm)								
Feed rate (kg/min)	**600**	**700**	**800**	**600**	**99.63[b]**	**4**	**99.55[b]**	**FST**	**99.5[a]**
4	99.46[bc]	99.42[c]	99.77[a]	700	99.63[b]	6	99.71[a]	JRDMCT	**100[a]**
6	99.68[ab]	99.64[abc]	99.80[a]	800	99.81[a]	8	99.77[a]	JRC	**100[a]**
8	99.75[a]	99.72[a]	99.85[a]						
SE			0.1294		0.0747		0.0747		0.0747
LSD			0.6806		0.0128		0.0124		
CV									0.28

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Cleaning Efficiency

The maximum cleaning efficiency of the machine was about 96.80% which is observed from Jimma rice thresher (JRC). This cleaning efficiency was not significantly different among feed rate, speed, and types of thresher **mean.**

Feed rate x speed				Speed (rpm)	Mean	Feed kg/hr	Mean	Type	Mean
	Speed(rpm)								
Feed rate (kg/min)	600	700	800	600	93.96^{a}	4	93.46^{a}	FST	91.91^{b}
4	95.28^{a}	93.50^{ab}	91.61^{b}	700	92.65^{a}	6	93.72^{a}	JRDMCT	90.20^{b}
6	95.28^{a}	92.28^{ab}	93.61^{ab}	800	92.30^{a}	8	91.72^{b}	JRC	**96.80^{a}**
8	91.32^{b}	92.16^{b}	91.69^{b}						
SE			1.5038		0.8682		0.8682		0.8682
LSD			0.1979		0.1405		0.0503		
CV									3.43

Mechanical grain damaged

The maximum percent of mechanical grain damaged of the machine was about 4.81% which is observed from Jimma rice thresher (JRC). This percent of mechanical grain damaged was not significantly different among feed rate, speed, and types of thresher mean.

Feed rate x speed				Speed (rpm)	Mean	Feed kg/hr	Mean	Type	Mean
	Speed(rpm)								
Feed rate (kg/min)	600	700	800	600	00.00^{b}	4	1.58^{a}	FST	00.00^{b}
4	00.00^{b}	2.01^{ab}	2.74^{a}	700	2.03^{a}	6	2.11^{a}	JRDMCT	00.00^{b}
6	00.00^{b}	3.15^{a}	3.19^{a}	800	2.51^{a}	8	1.11^{a}	JRC	**4.81^{a}**
8	00.00^{b}	1.74^{ab}	1.60^{a}						
SE			0.5621		0.5621		0.5621		0.5621
LSD			0.7283		0.0000		0.2100		
CV									128.56

IV. CONCLUSION AND RECOMMENDATION

Conclusion

- According to the result,Fadis sorghum thresher (FST) had threshingcapacity; threshing efficiency; cleaning efficiency, and percent of damaged grain were 394.12kg/hr at 8kg/min feed rate and 800 rpm, 99.5% at 8 kg/min feed rate and 800rpm,91.91 at 6kg/min feed rate and 800rpm, and00.00% respectively.
- Jimma rice thresher (JRC) had threshing capacity; threshing efficiency; cleaning efficiency and percent of damaged grain were 679.12kg/hrat 8kg/min feed rate and800rpm. 100%at 4kg/minfeed rate and 800rpm, 96.80% at 6kg/min feed rate and 700rpm and 4.81% at 4kg/min feed rate and 800 rpm respectively.

- Jimma replaceable Drum multi thresher (JRDMCT)had threshing capacity; threshing efficiency; cleaning efficiency and percent of damaged grain were 590.26kg/hrat 6kg/min feed rate and 800rpm, 100% at 4kg/min feed rate and 700rpm, 90.20% at 6kg/min feed rate and 700 rpm and 00.00% respectively.

Recommendation

The selection of these machines was made on threshing capacity, threshing efficiency, and cleaning efficiency. Therefore it was better to use the rice thresher than the other.

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