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Improvement Of Engine Driven Sorghum Thresher By Incorporating Grain Cleaning System

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ABSTRACT

The improved engine driven sorghum threshing machine was designed and produced at Fedis agricultural research center with the objectives of solving the critical threshing and cleaning problems of sorghum produce the farmers' and subsequently, to reduce the drudgery of the farmers', grain loss and cost of threshing, in comparison with traditional methods of manual threshing by using wood log. The developed machine was tested in east Hararghe Zone, Haramaya district, Horo Kebele. The variables considered includes two sorghum varieties (muria and fandisha), three levels of cylinder speed (500,700 and 900 rpm), three position of cylinder-concave clearances (13, 18 and 23 mm) and three feed rates of the un-threshed sorghum head (10 kg/min, 15 kg/min and 20 kg/min). The experimental design was split-split plot design with three replications. The result obtained indicated 87.28-95.30% threshing efficiency, 7-10 qt/h output capacity and 74%-88% cleaning efficiency at constant grain moisture contents of 15-17% for both varieties.

KEYWORDS

Sorghum thresher, threshing, Cleaning system, Improvement, Sorghum thresher.

INTRODUCTION

For millions of people in the semi-arid tropics of Asia and Africa sorghum is the most important staple food. This crop sustains the lives of the poorest rural people and will continue to do so in the foreseeable future. Sorghum grows in harsh environments where other crops do not grow well (FAO, 1990). The traditional method sorghum threshing is laborious, time consuming and uneconomical. This method of threshing consumes more time, compared to other mechanical threshing method. Using this method a farmer can obtain 15 - 40 kg of grain per hour (FAO, 1990). Traditional threshing method also causes grain loss, to the extent of 6% (Miah, 1990).Threshing operations of agricultural crop produce leave all kinds of trash mixed with grain; they comprise both plant materials (e.g. foreign seeds or kernels, chaff, stalk, empty grains, etc.) and mineral materials (e.g. earth, stones, sand, metal particles, etc.), which can adversely affect subsequent storage and processing conditions of the food grain. Totally, a traditional method of threshing and subsequent cleaning of grains is physically demanding and energy consuming (Ali, 1986). The cleaning operation aims at removing as much trash as possible from the threshed grain (FAO, 1990). Cleanliness is an important quality characteristic for market acceptance of food products. One of the most important valuable additions is reduction of the contaminant to the minimum. Rooney (2003) reported that a major limitation in producing excellent food products from sorghum is a lack of consistent supply of good quality grain for processing. Contaminants affect the quality of grains and make grains less attractive in appearance therefore they constitute easy habitants for pests, increase handling cost, and ultimately cause low market value (HurburghJr, 1995).

The cleaning process is a mass transfer process involving segregation of particles on a pan before coming to the air stream, motion in the air stream and motion after coming out of the air stream (Kashayap and Pandya, 1965). Knowledge of the dynamics of grain air interaction is essential to adequately understand the cleaning process and to design appropriate cleaning equipment (Freltag, 1968). Modeling the cleaning process in a stationary thresher would help to save energy consumption, thereby reducing the time and cost of winnowing when the knowledge gained is put to use. Thus, the objective of this study is to incorporate the cleaning system to the sorghum threshing machine for increasing cleaning efficiency of the machine and to evaluate the performance of the machine.

MATERIAL AND METHOD

Experimental Design

The mathematical expression for cleaning efficiency (η) between the dependent and independent variables given by Simonyan (2006) is:

$$\eta = f_e\left(\theta_g, \theta_s, \beta_g, \beta_s, f_r, \alpha, V_t, D, V_a, P_p\right) = 74 - 88\,\% \qquad (1)$$

Where, η = cleaning efficiency (%), θ_g = grain moisture content (%) w b, θ_s = straw moisture content (%) w b, β_g = grain bulk density (kg/m^3), β_s = straw bulk density (kg/m^3), f_r = feed rate (kg/s), α = sieve oscillating frequency (1/s), V_t = cylinder speed (m/s), D = diameter of sieve hole (m), V_a = air velocity (m/s) and P_p = particle density (kg/m^3).

The diameter of sorghum grain was calculated tri-axially (along its three axis) and geometric mean diameter d_e by Mohsenin, (1980).

$$d_e = (\mathrm{abc})^{1/3} = 3.1\ \mathrm{mm}^3 \qquad (2)$$

Where, a, b, c = diameters along three axes.

The bulk density of the sorghum grain and straw were determined using the following formula (Mohsenin, 1980).

$$\beta = \frac{m}{v} \qquad (3)$$

$\beta_g = 424\ kg/m^3$ for the grain and $\beta_s = 25.48 kg/m^3$ for the straw

Where: m = mass of grain, chaff or straw (kg), v = volume of container (m^3)

Moisture content of samples was determined using Dole 400'moister tester ($= 15 - 17\%$) and can also be determined the method by Henderson et al (1997).

$$MC_{wb} = \frac{W_i - W_d}{W_i} \times 100 \qquad (4)$$

Where: MC_{wb} = Moisture content, wet basis, %, W_i = Initial weight of sample, kg and

W_d = dried weight of sample, kg

Cleaning efficiency (Purity) was obtained by the following formula

$$\eta = \frac{G_o}{G_o + C_{cg}} \times 100 \quad = 74 - 88\% \qquad (5)$$

Where: η = cleaning efficiency, %, G_o = weight of pure grain at the outlet, kg and

C_{cg} = weight of contaminant, kg.

Linear Velocity for a rotating shaft with speed n and pulley of radius r was calculated by

$$V = \frac{2\pi rn}{60} \quad = 6.13\ m/sec \qquad (6)$$

Where: V = velocity, m/s, n= speed in revolutions per minute, rpm

The sieve oscillation frequency, α, was calculated by formula

$$\alpha = \frac{N}{t} = 10.4/sec \qquad (7)$$

Where: N = number of reciprocations, t = time in seconds

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EXPERIMENTAL MATERIAL

The experimental materials are the developed sorghum thresher (Figure.1), sorghum panicles of the locally available varieties, 8 hp Kama engine, 'Dole 400'moister tester and a stopwatch The variety of sorghum that was tested at the time of experiment were *Muira* and *Fendisha*.

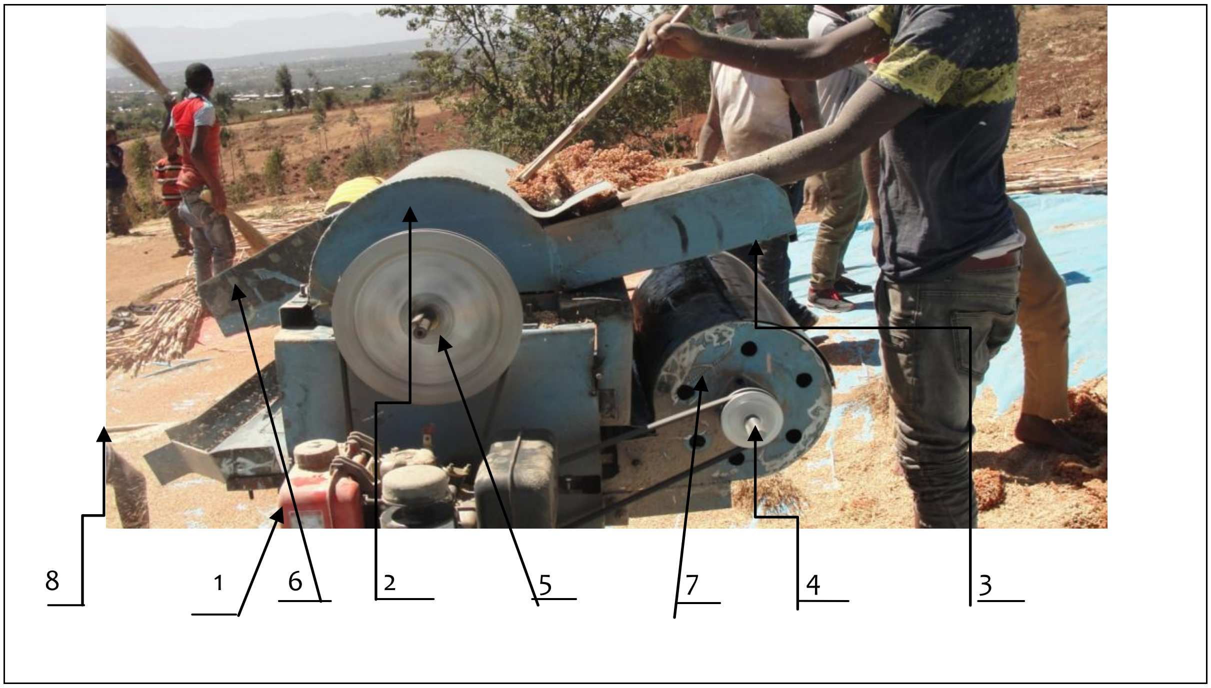

Figure.1 Engine driven sorghum thresher

1. Engine
2. Drum upper cover
3. Feeding chute
4. Fun pulley
5. Drum pulley
6. Straw outlet
7. Funsystem
8. Grain outlet

The improvement work done

The improvement of the machine was to incorporate the cleaning system since the machine doesn't have cleaning part. Therefore according to its design made the fun, the eccentric shaft air deflector and the sieve components were made in the work shop then assembled and fixed on the machine. The cleaning system which was attached on the machine can get power from drum pulley and perform the cleaning activity. Due to the cleaning system the machine performance was changed, see table1 below.

Table1: The performance of the machine before and after improvement.

Threshing efficiency (%)	Cleaning efficiency (%)	Threshing Capacity Kg/hr	Threshing efficiency (%)	Cleaning efficiency (%)	Threshing Capacity Kg/hr
88.97to 97.08	-	600 to 836	87.28 to 95.30%	74% to 88%	700 to1000

Experimental Site

The performance test of the machine was done in east Hararghe zone, Haramaya district at the place known as Ganda Horo, which is nearest to Awaday town. The site is the major sorghum growing area in the zone. The experiment was done by using the farmer's harvest.

Experimental Method

The thresher is derived with 8 hp kama engine and moisture content of the sorghum grain was in a range of 15-17%. Two sorghum varieties; Muria and Fandisha, three different cylinder (an axial-flow spike tooth type) concave clearance of 13 mm, 18mm and 23 mm, three levels of cylinder rpm 500, 700, and 900 and three levels of sorghum panicles feed rates;10kg/min, 15 kg/min and 20 kg/min were used for the testing of the machine. The selected experimental design for this study was split-split plot design with three replications.

During the test operations, the selected weight of sorghum panicles were fed through the inlet part of the machine by an operator and the threshed outputs were collected from the outlets. Three samples were taken from each test of main and straw out let. From each sample pure, with glum, un-threshed and broken grain were separated, weighed and then, the result was recorded. The above procedure was repeated thrice for all combinations of sorghum variety with cylinder-concave clearance, rpm and feed rate. The selected design was used to analyze the obtained data during the experiment. Accordingly, the two sorghum varieties were taken as the main plot treatment factors, three cylinder-concave clearances as sub-plot treatment factors, three rpm as sub-plot-plot and three feed rates as sub-plot-plot-plot treatment factors with three replications as block. To analyze the treatment factors by split plot design laid down (2x3x3x3) x3 factorial combinations with three replications, which result 162 numbers of trials.

RESULTS AND DISCUSSIONS

The statistical analysis showed that the coefficient of variation (CV) was 1.72% for pure grain, 30.28% for grain with glum and 25.42% for un-threshed grain. Least significant deferent (0.05) values for pure, with glum and un-threshed grain were 0.386, 0.389 and 0.058 respectively. During the test it was observed that the threshing efficiency of the machine was varied in a range of 87.28% to 95.30%.

Maximum threshing efficiency of 95.30% was obtained for fandisha variety at speed of cylinder 900 rpm, 13 mm cylinder-concave clearance and feed rate of 10 kg/min. The 87.28 % or minimum threshing efficiency of the machine was observed at feed rate of 20 kg/ min, 500 rpm and concave clearance of 23 mm. The highest un-threshed grain of 1.32% was noticed at feed rate of 20 kg/min, 500 rpm speed of the cylinder and cylinder-concave clearance of 18 mm. However, the lowest un-threshed grain percentage was 0.43% obtained at the feed rate of 10 kg/min, 900 rpm speed of the cylinder and cylinder-concave clearance of 13 mm. From this result it can be generalized that threshing efficiency increases with increasing cylinder speed in a given range. Increasing feed rate raises threshing efficiency to certain limit and then decreases. Increasing cylinder-concave clearance decreases threshing efficiency and also, results in more un-threshed grain on the sorghum head.

For muiraa variety maximum threshing efficiency (95%) was recorded at feed rate of 10 kg/min and 900 rpm speed of cylinder and cylinder-concave clearance of 13 mm, While, the minimum threshing efficiency (87.28%) was recorded at a feed rate of 15 kg/min , 500 rpm speed of cylinder and 23 mm cylinder-concave clearance. Broken grain was in contrary with un threshed grain in such a way that, its value was increased by increasing cylinder speed. The output capacity of the machine was varied from 7-10 qt/h for muira and fendisha. Due to the nature of its head, muira showed the utmost output capacity of the machine than fendisha. Cleaning efficiency of the machine was obtained between 74%-88%. Broken grain was 1.5% and average fuel consumption of the diesel engine was 0.12 lit/qt.

CONCLUSION AND RECOMMENDATION

The improved sorghum thresher with cleaning system was found to be better in threshing capacity of 7-10 qt/hr as compared to threshing done by hand. The obtained threshing efficiency is between 90 to 95.3%. Cleaning efficiency of the machine was obtained between 74-88%. It needs farther improvements to attain the permissible percentage 95%. The optimum conditions for thresher evaluation were set for threshing efficiency and cleaning efficiency being 95% (Singhal and Thierstein, 1987). Broken grain was 1.5 % which is below the standard of 2% maximum (Sharma et al., 1984). To get maximum efficiency and output capacity users should adjust the cylinder speed on 900 rpm, concave-clearance on 13 mm and feed rate at 10 kg/min for both muira and fendisha and considering recommended moister content of the grain. Since the obtained machine's performances were found to be in the acceptable ranges and taken as good results, so it is recommended that, the machine should be multiplied and promoted (disseminated) for farmers, to reduce the drudgery of sorghum threshing and grain losses.

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