



## **EVALUATION OF A LOCALLY MANUFACTURED MAIZE THRESHER IN SUNYANI WEST MUNICIPALITY OF GHANA**

**Akolgo G.A.<sup>1</sup>, Essandoh, E.O.<sup>2</sup>, Atta-Darkwa, T.<sup>3</sup>, Uba, F.<sup>4</sup>, Kemausuor, F.<sup>5</sup> and Akimsah, J.<sup>6</sup>**

<sup>1,2,3,4&6</sup>*Department of Mechanical and Manufacturing Engineering, University of Energy and Natural Resource, Sunyani, Ghana.*

<sup>5</sup>*Department of Agricultural and Biosystems Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.*

[gilbert.akolgo@uenr.edu.gh](mailto:gilbert.akolgo@uenr.edu.gh)

### **ABSTRACT**

*Processing Maize to improve its quality does not only prolong its useful life but also increases the net profit farmers make and the goodwill derived from consumers. In this study, the emphasis was placed on field evaluation of a locally manufactured motorized maize thresher in Sunyani West Municipality of Ghana. The main objective of the project is to analyze and evaluate a motorized maize thresher for farmers in Sunyani West Municipality of Ghana. The methods used involved the collection and collation of threshing parameters such as threshing speed, maize moisture content for good threshing as well as taking appropriate measures such as reduction of quantitative (Un-threshed Grains and Scatter) and qualitative (mechanical grain damage) losses, and utilizing theories and mechanisms in threshing to determine various threshing parameters. The evaluation of the thresher involved the varying of the shelling shaft speed from 700 rpm to 900 rpm at different maize moisture contents ranging from 13% to 20%. The results showed that the maximum shelling efficiency and throughput capacities were 98.7% and 1737 kg/h respectively at 13% moisture content of maize and a shelling speed of 900 rpm.*

**Keywords:** *Maize Threshing, Evaluation, Shelling Efficiency, Grain Damage and Shelling Shaft Speed*

### **INTRODUCTION**

Maize production in Ghana is of great importance since the market demand for maize grain keeps increasing with the current national annual consumption rate of about 1,900,000 MT (Ghana Corn Domestic Consumption, 2018). Maize shelling (also known as threshing) in developing nations such as Ghana has been and remains a serious problem. It is tedious and often requires considerable labour hours (Aremu, Adewumi, & Ijadunola, 2015) to execute. Hence, it is important to look at the way maize in Ghana are mechanically threshed since many operators have little technical knowledge about threshing at the proper feed rate, moisture content and optimum performance speed to produce quality maize that would attract high market value. Over the past few years,

ISSN: 2408-7920

Copyright © African Journal of Applied Research

Arca Academic Publisher



Ghana has been losing 318,514 tons of maize annually to post-harvest losses which threshing losses are part (Bruno, 2017).

Shelling is an indispensable process, undertaken to maximize space utility and promote the easy handling of grains either storing them in silos or bagging them. Maize shelling, if done manually is one of the most labour-consuming corn post-harvest handling processes but the most efficient method for preventing grain damage. A better performance from a mechanical maize thresher is easily achievable if a definite relationship between shelling speed, moisture content of grains and feed rate is established. This research was conducted based on the problems stated below:

- Traditional threshing methods do not support large-scale threshing of maize
- Hand threshing takes a lot of time
- Tractor mounted threshers damage maize seeds and are highly expensive for small-scale farmers/ rural farmers.
- Thresher operators have little knowledge of the moisture content, threshing speed and rate of feed to threshing output.
- Lack of appropriate threshing guidelines for the use of maize thresher operators in Ghana.
- Locally manufactured threshers have no research data on their optimum operating conditions.

Due to these problems, the need to conduct a thorough exercise that would lead to the improvement of the working rate of the locally manufactured motorized maize threshers, minimizing grain losses and increasing the good quality output of threshed maize is very necessary. The study also analyzed and evaluated the performance of the locally manufactured motorized maize threshers.

Chowdhury and Buchele in their study stated that threshing processes that required four days to accomplish using local practices would take less than two hours using satisfactory mechanically operated threshers (Chowdhury and Buchele, 1978).

Kepner, Roy and Barger, (1972) stated that the cylinder speed primarily influences the damage caused to the seed when compared to the influence of concave clearance on seed damage.

Al-Jalil, Marley, & Chowdhury, (1980) Reported about the development of a new power thresher that could reduce grain damage and broken corncobs. The basic principle of this new machine is to get the normal stress reduced by developing a concave system that could vibrate without causing a great impact on the maize grain during the shelling process.

Olanyanju Adewuyi, & Omotayo, (2009) in their work compared thresher efficiency to the amount of damaged grain. It was observed that a high drum speed and low concave clearance gave rise to an increase in the damage of threshed grains and power required.

Coskun Yalçın, & Özarslan, (2006) reported that the factors influencing the threshing ability of maize in Nigeria are field drying, maize varieties, ear-size cylinder speed and feed rate. The



properties of the crop that affect the thresher performance are crop variety, shape and size, the hardness of the seed, the moisture content of the seed and the density.

Mady, (2004), studied the percentage of corn grain damage caused by the cylinder and thresher concave before and after the grains were threshed from the cob. The effect of grain moisture content and cylinder velocity on grain damage was also investigated. Cylinder velocity of 7 m/s and 11 m/s were used in the threshers. Varieties of corn were threshed with the grain moisture content of 15%, 20% and 25%. Damaged grain percentage increased with an increase in moisture content and cylinder velocity (Mady, 2004).

Mechanical damage was also affected by the concave clearance, physical and morphological properties of corn ear and feeding rate. Darudkar, Handa, Darudkar, & Handa, (2015) found that kernel moisture content and cylinder speed were highly significant in the analysis of variance for damaged corn kernel percentages, with total damage increasing from 26% to 41% as cylinder velocity increased from 450 to 650 rpm (12.8 and 18.7 m/s). Minimum total damage was sustained at 23% moisture content (w.b) and it was found that the mechanical damage caused by a laboratory thresher ranged between 26.3 and 42 percent of cylinder velocities. Ghatrehsamani, Ampatzidis, Sadeghi & Ghatrehsamani (2018) designed, constructed and evaluated a corn sheller. The highest efficiency of a separation unit was calculated to be 95.909 % and maximum loss of 4.832%. Performance evaluation of a motorized maize thresher carried out by Mashood *et al.*, (2019) recorded the highest threshing efficiency as 99.73%.

The literature reviewed in this study point to the fact that dependent variables such threshing efficiency, threshing capacity, grain damage, threshing loss are influenced by independent factors such as drum speed, moisture content and concave clearance. Past research works, revealed a strong relationship between these dependent and independent variables in respect of maize threshing. This background forms the foundation of the hypothesis of this study. The hypothesis of this study states that maize shelling is appropriately done at moisture content below 13 % and shaft speed of 900 rpm and this was investigated. This study was necessary because there has been no study that has evaluated the performance of locally manufactured motorized maize threshers in Ghana. This study will close the knowledge gap that exists concerning the evaluation of locally manufactured threshers. It is expected that the findings of this study will help farmers and researchers in Ghana who is working in the area of maize shelling/threshing.

## **CONCEPTUAL FRAMEWORK FOR FIELD EVALUATION OF MAIZE THRESHER**

The theoretical conceptual framework for this study is based on the works of Dula, (2019), Mashood *et al.*, (2019), Ghastrehsamani *et al.*, 2018 who conducted various studies on the evaluation of maize threshers.

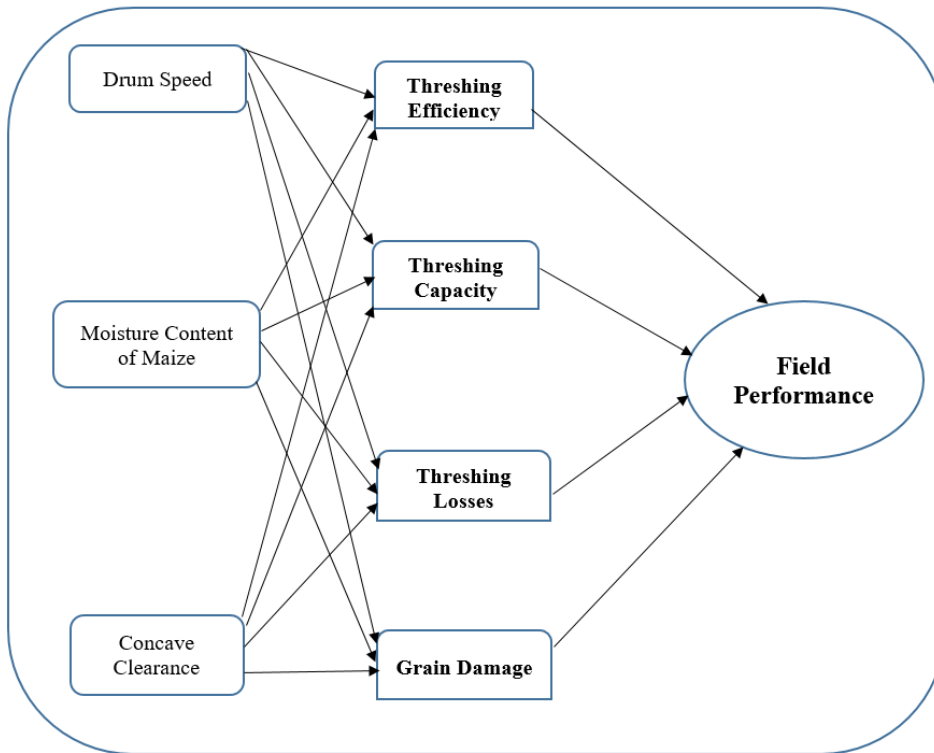
ISSN: 2408-7920

Copyright © African Journal of Applied Research  
Arca Academic Publisher



The conceptual framework for this research is primarily based on the foundation that the performance of maize threshers strongly relates to indicators such as threshing efficiency, threshing capacity, grain damage and threshing loss. The researchers also identified independent variables such as drum speed, moisture content and concave clearance which influence the dependent variables.

Grounded on the fundamental factors associated with all the earlier frameworks, this current study looks at the relationship of the threshing efficiency, threshing capacity, grain damage and threshing loss and drum speed, moisture content and concave clearance, which are the essential variables that the majority of previous studies have measured on the performance of threshers as shown in Figure 1.



*Figure 1: Conceptual Framework of the evaluation of maize threshers*

## **MATERIALS AND METHODS**

Odumasi maize market in Sunyani West Municipal in the newly created Bono Region of Ghana was identified and selected for this case study because of the availability of locally fabricated maize shelling machines in this market. The market has a population of about 10 locally

ISSN: 2408-7920

Copyright © African Journal of Applied Research

Arca Academic Publisher



manufactured maize shellers. This place was chosen for the field study of this research because of the intensive use of locally manufactured motorized maize shellers/threshers at the place. The convenience sampling technique was used in the study to select three threshers out of a thresher population. Also, the Bono Region is known to be a leading producer of maize (Adu-Gyamerah, 2017 and Amanor, 2013).

### **Materials Description in The Research**

The materials that were used in this study are described in this section.

#### *Tachometer*

This instrument was used in measuring the rotational speed of the shaft of the thresher. The device usually displays the revolutions per minutes (RPM) of the rotating member (shaft).

#### *Beam Balance*

The beam balance is a device used for the determination of the mass of a body as shown in Figure 2. In this research, it was used to determine the mass of the maize used in the threshing operation.



*Figure 2: The beam balance*

#### *Moisture Meter*

The moisture meter is a device that was used to measure the percentage of moisture in the maize grains. A digital portable multi-grain moisture meter was used in this study to measure the moisture content of grains.



### *Motorized Thresher*

A four-wheeled motorized maize thresher (Figure 3) designed and constructed by the Sunyani Branch of Ghana Regional Appropriate Technology and Industrial Service (GRATIS) Foundation, was employed in carrying out this research. It is powered by a petrol engine and develops a shaft power for threshing. Some of the key parts of the thresher are hopper, motor, pulley, drum beater, blower and a delivery unit or output discharge tray.



*Figure 3: Motorized Maize Thresher*

### *Methods Used In The Study*

After a preliminary set up, maize cobs were weighed on the beam balance and then fed into the hopper continuously. The rotating peg teeth of the thresher produced two kinds of forces namely impact and shearing which caused the shelling of the maize from the cobs. The outlet door was then opened and kernels were collected at the end of the shelling process with the help of the measuring container. Two labourers were engaged for these operations, one for feeding maize cobs into the hopper and the other for opening the outlet door and collecting the grains at the outlet. Weight of whole grains, broken grains and unshelled cobs were recorded separately, and time of operation to calculate throughput capacity and efficiencies were also recorded. While in operation, the cylinder speed was also recorded using the tachometer. In the end, a sample of maize grain was taken to the laboratory and the moisture content of the grains were determined with the help of the moisture meter.



A Flowchart of the methodology of this study is shown in Figure 4.

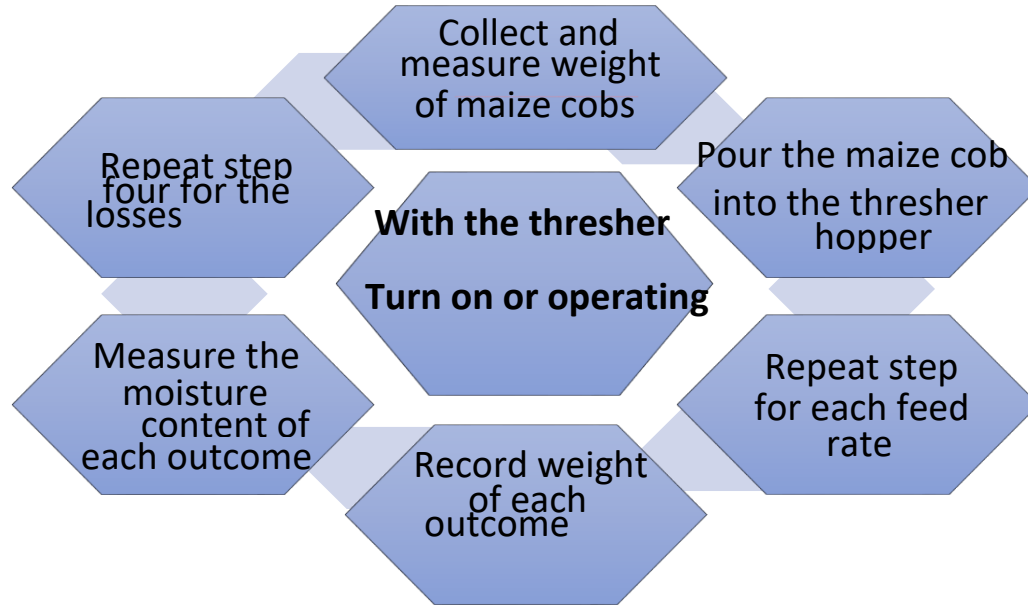


Figure 4: threshing flow chart

**Data Classification And Analysis**

The procedure for threshing maize was repeated for all the combinations of treatments i.e. at different moisture contents and speeds and the data were recorded. The following parameters were recorded during the threshing:

- Weight of kernels cob fed through the hopper (Wt.)
- Weight of kernels shelled at main grain outlet (Wk)
- Weight of damaged kernels (Wd)
- Weight of unshelled kernels cob at all outlets (Wu)
- Weight of kernels collected at dust outlets (Wb)
- Time of operation (h)
- The moisture content of grains
- Speed of cylinder ( rpm)

With the above data, the following parameters were then computed:

*Un-threshed grain (un-th gr)*

$$\text{Un-threshed grains (\% by weight)} = \frac{\text{weight of unshelled grains(kg)}}{\text{weight of total grain fed(kg)}} \times 100\% \dots \dots \dots \text{eqn. 1}$$





*Shelling Efficiency*

Shelling efficiency is the ratio of the quantity of threshed grains collected to the total quantity fed into the thresher before threshing and is mathematically expressed as:

$$SEFF = \frac{(Mt - Mun)}{(Mt)} \times 100 \dots\dots\dots \text{eqn. 2}$$

where SEFF = shelling efficiency, %, Mun = mass of unshelled grains, kg, Mt = Mass of total grains fed, kg.

*Mechanical Efficiency*

The mechanical efficiency is mathematically expressed as:

$$MEFF = \frac{(\text{shelled grains at outlet})}{(\text{shelled grains at outlet} + \text{scatter loss})} \times 100 \dots\dots\dots \text{eqn. 3}$$

where, MEFF = mechanical efficiency, %

*Scatter losses*

One of the losses encountered in a threshing operation is scattered loss and is mathematically defined as:

$$SC\ LSS = \frac{(\text{Mass of grain scattered})}{(\text{Mass of total grain fed})} \times 100 \dots\dots\dots \text{eqn. 4}$$

where, SC LSS = scatter losses

*Mechanical Grain Damage (ME GRD)*

Mechanical grain damage is a parameter used to determine the quantity of visible physical damage or breakage done to grains that can be attributed or assigned to the thresher. The mechanical grain damage is given as;

$$ME\ GRD = \left( \frac{\text{Mass of grain damaged}}{\text{total grains collected}} \right) \times 100\% \dots\dots\dots \text{eqn. 5}$$

where ME GRD = Mechanical grain damage (in percent),

*Throughput capacity (TC)*

The machine throughput capacity was given by (Baryeh, 2002). It is the actual amount of grains threshed and collected by a thresher per unit time.

$$Tc = \frac{\text{Mass of grain collected at the grain outlet}}{\text{Time taken to thresh in hours}} \dots\dots\dots \text{eqn. 6}$$

where, TC = Throughput capacity expressed in kilogram per hour (kg/h)

ISSN: 2408-7920

Copyright © African Journal of Applied Research

Arca Academic Publisher





## RESULTS AND DISCUSSION

Based on the motorized maize thresher performance characteristics, the results of its field evaluation at three different moisture contents as well as different threshing speeds were captured in Table 1. The field evaluation was performed to determine the most appropriate moisture content of maize and the optimum speed at which the thresher has to operate to ensure its most efficient performance.

*Table 1: Field evaluation results of the locally manufactured motorized maize thresher evaluated by this study*

<b>Cylinder speed (rpm)</b>	<b>900</b>			<b>800</b>			<b>700</b>		
Wt. of maize fed to the Thresher (kg)	23			23			23		
Moisture contents (%)	13	15	20	13	15	20	13	15	20
Wt. of Threshed maize(kg)	19.3	18	16.1	19.2	18.3	16.8	19.3	19	18
Wt. of damaged grains (kg)	0.1	0.23	0.73	0.1	0.18	0.66	0.08	0.23	0.43
Wt. of whole grains (kg)	19.2	17.8	15.35	19.11	18.12	16.14	19.22	12.8	17.57
Wt. of cobs (kg)	3.05	3.6	4.5	3.06	3.5	4.50	3.09	3.31	4.5
Un-threshed grains (kg)	0.3	0.85	1.50	0.31	0.7	0.9	0.4	0.45	0.29
Scattered losses (kg)	0.25	0.55	1	0.23	0.5	0.8	0.21	0.24	0.21
Time taken (s)	40	50	69	60	72	111	90	120	164
Shelling efficiency (%)	98.7	96.3	93	98.6	96	96	98.3	98.6	98.7
Mechanical efficiency (%)	99	97	94.2	98.8	97.3	95.4	98.9	98.9	98.8
Mechanical grain dam. (%)	0.5	1.3	4.5	0.5	1	3.9	0.41	0.8	2.37
Whole grains (%)	99.5	98	95.5	99.5	99	96.1	99.59	99.2	97.63
Scatter losses (%)	1.1	2.4	4.3	1	2.2	3.5	0.9	1	0.9
<b>Throughput capacity(kg/h)</b>	<b>1737</b>	<b>1296</b>	<b>s 840</b>	<b>1152</b>	<b>915</b>	<b>545</b>	<b>772</b>	<b>570</b>	<b>396</b>

The field test also enabled the researchers to determine the quantity of maize to be threshed to minimize the qualitative and quantitative grain loss. The highest shelling efficiency, mechanical efficiency, and the percentage whole grain of the thresher performance occurred at the highest

ISSN: 2408-7920

Copyright © African Journal of Applied Research

Arca Academic Publisher



speed of 900 rpm, at 13% moisture content however the lowest shelling, mechanical efficiency, and the percentage whole grain also occurred at the same cylinder speed at higher moisture content as shown in Figures 5, 6 and 7.

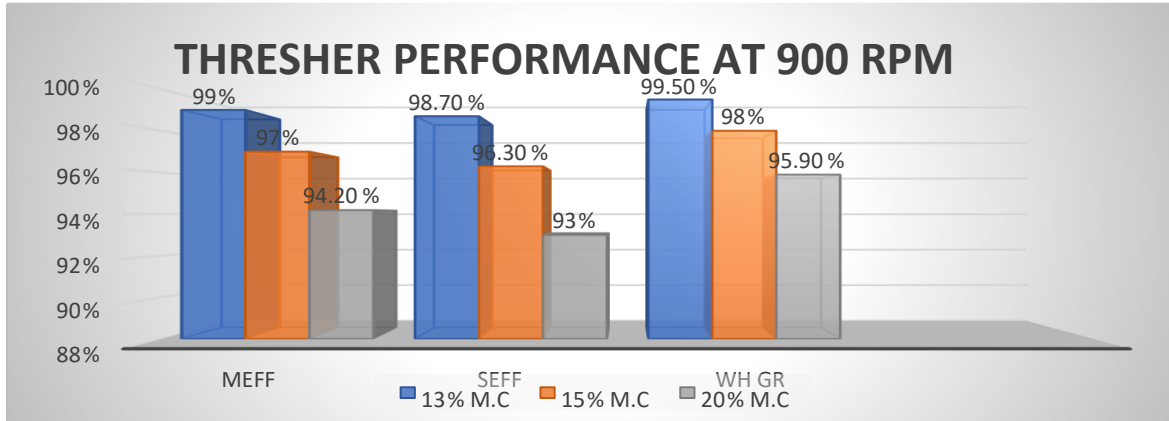


Figure 5: A graph of shelling, mechanical efficiency and percentage whole grain at 886 rpm

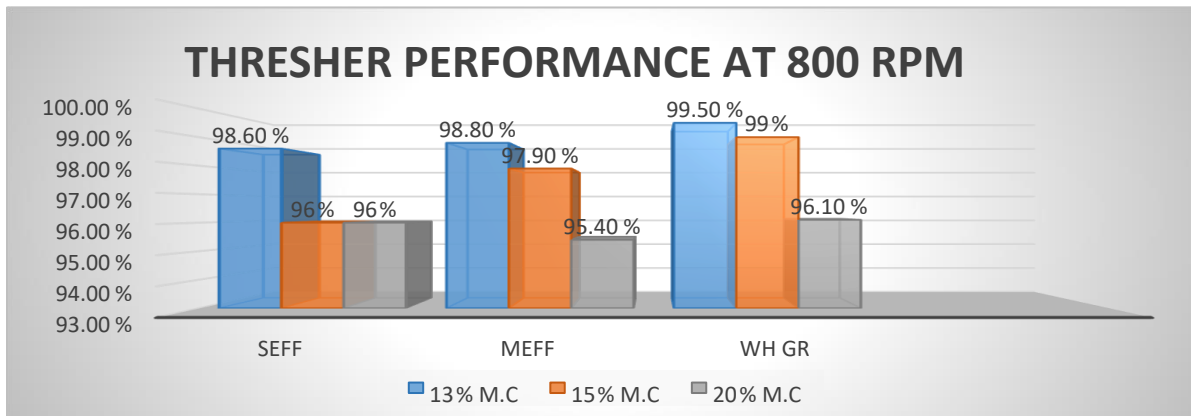


Figure 6: A graph of shelling and mechanical eff with whole grain at 800 rpm.

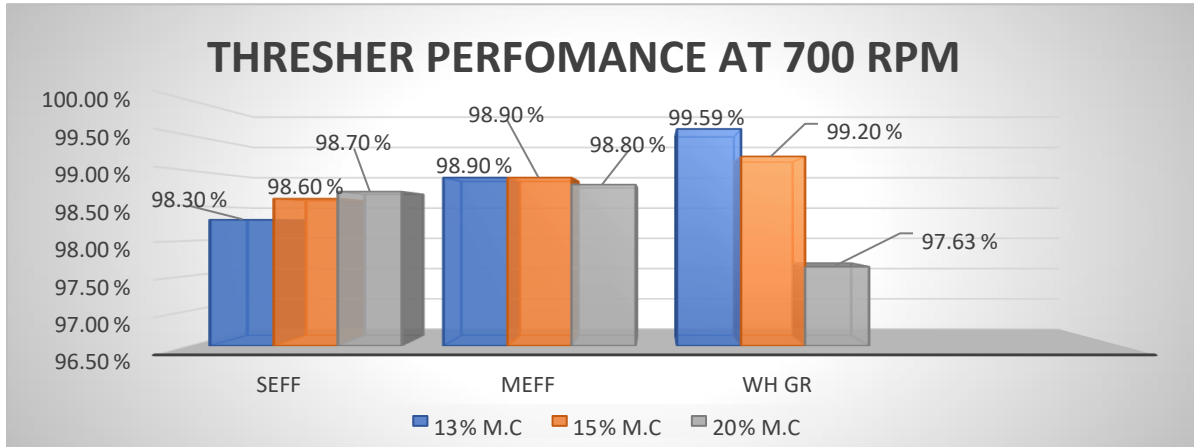


Figure 7: A graph of shelling, mechanical efficiency and percentage whole grain at 680 rpm.

This essentially means that the threshing efficiencies generally increased with increasing cylinder speed of the motorized maize thresher at all levels of MC, which supports the findings made by Naveenkumar, (2011) and Abarchi, (2011).

Again, the amount of percentage un-threshed grain decreased with increasing thresher speeds from 700 rpm – 900 rpm which supports the finding of Kepner *et al.*, (1972) who found out that threshing speed increases the performance of threshers but broken threshed grains were more at higher speeds, though threshing at higher speeds gives higher throughput capacity as shown in Figure 8, 9 and 10.

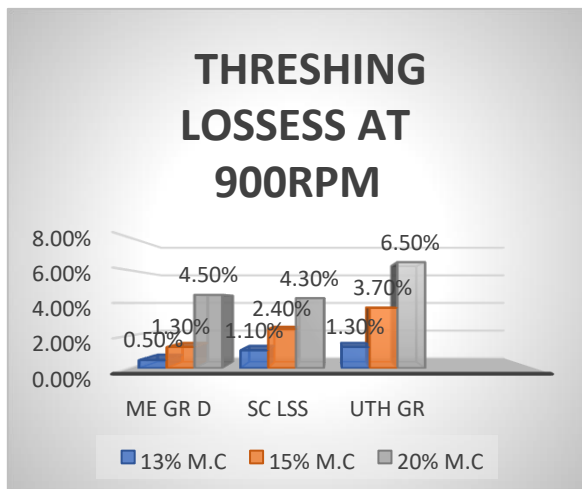


Figure 8: Loss at different M.C. at 900 rpm

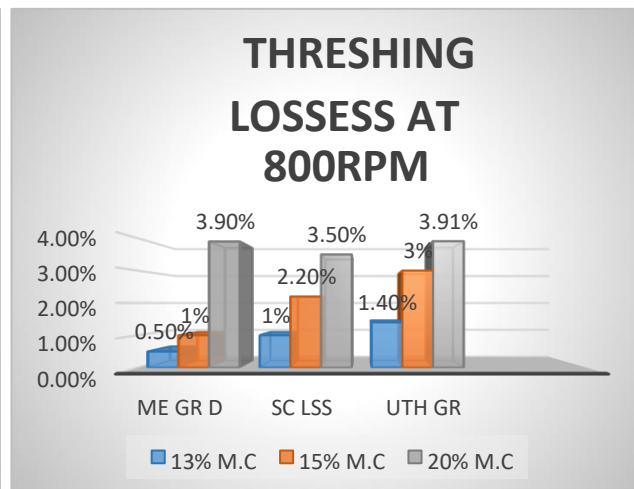


Figure 9: Loss at different M.C. at 800 rpm

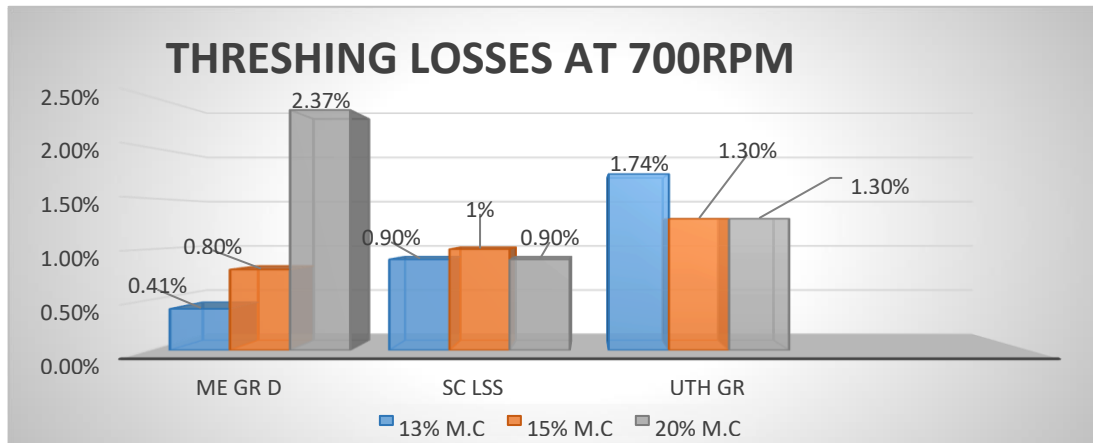


Figure 10: A graph of scattering losses and grain damage with unthreshed at 700 rpm

### EFFECTS OF VARYING SPEED AND MOISTURE CONTENT ON THROUGHPUT CAPACITY.

Figure 11 is a graph of throughput capacity with varying speeds and moisture contents. The throughput capacity increases with increasing thresher speeds and vice versa at decreasing moisture contents. The highest throughput capacity is 1737 kg/h which occurred at 13% moisture content with a cylinder speed of 886 rpm and the lowest capacity is 396 kg/h which occurred at 20% moisture content and 700 rpm cylinder speed. This is because threshing at low moisture content requires a smaller amount of energy than at high moisture content and again threshing at high threshing speed delivers a greater torque or force than at lower speed. Tastra (2009) and Abarchi (2011) reported that throughput capacity would increase with an increase in the operating speed of a thresher thus corroborating our findings. Kepner *et al.*, (1972) found out that threshing at higher speeds enhance the performance characteristics of threshers but the threshing process ended up with more broken grains, especially at higher moisture contents. However, at a higher cylinder speed, better throughput capacity, shelling efficiency and percentage whole grains are obtained at the end of the threshing operation.

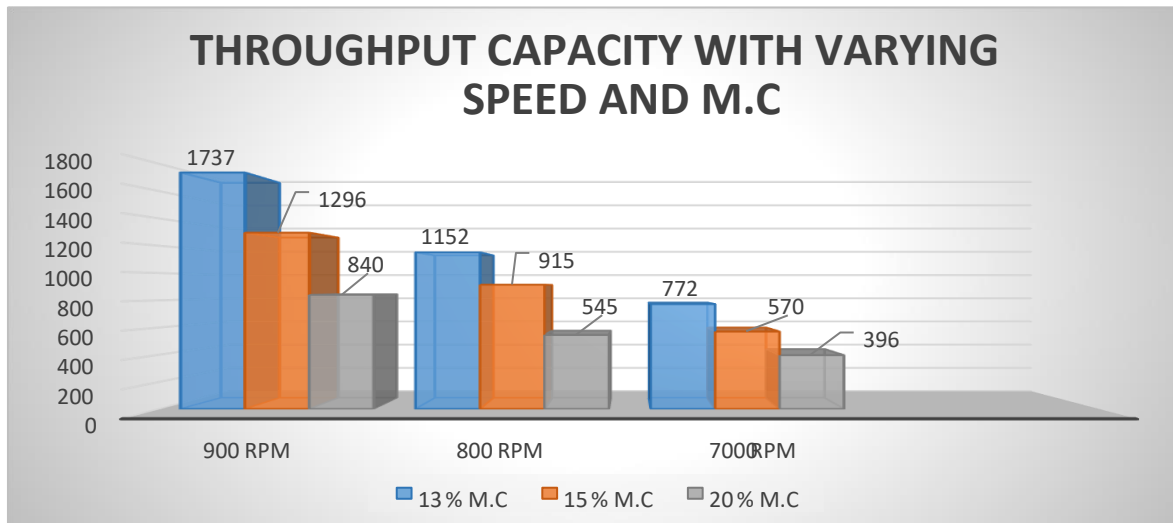


Figure 11: A graph of throughput capacity with varying speed and moisture content

## CONCLUSION AND RECOMMENDATION

A locally manufactured motorized maize thresher was assessed and evaluated at Odumasi maize market in Bono Region of Ghana. Some important issues were considered concerning the study of shelling maize from its cob. The objectives of the study which included to determine the effect of varying thresher speed and varying moisture content on grain losses were achieved.

Threshing maize at 13% moisture content and a cylinder speed of 900 rpm yielded the optimum throughput capacity as compared to 15% and 20% moisture content. 1737 kg/h was obtained for 13% MC, 1296 kg/h for 15% MC and 840 kg/h for 20% MC as the respective production rates of the thresher at a selected speed of 900 rpm.

When threshing maize cobs with high moisture content, it is important to thresh them at the lowest cylinder speed to minimize grain damage and scatter losses as indirectly depicted in Figure 8. This means that the time required for threshing will increase which in turn will reduce the throughput capacity.

When threshing maize cobs and aiming at the highest shelling efficiency, mechanical efficiency and percentage whole grain, it is important to thresh grains at 13% moisture content and at a speed of 900 rpm in the case of the locally manufactured motorized maize thresher. The finding of this study can help farmers in Ghana minimize threshing losses in their farms. This implies that policymakers need to create a system that will avail the optimum moisture content, shaft speed



and feed rate levels to farmers. This system will help farmer using the locally manufactured maize Sheller minimize the losses recorded during maize shelling/threshing operations.

## REFERENCES

- Abarchi, S., (2011). Improvement of the Design and Construction and Performance Evaluation of a Small Scale Power Operated Millet Thresher, Zaria: Unpublished B. Eng Project Submitted At Department of Agricultural Engineering A. B. U.
- Al-Jalil, H. F., Marley, S. J., & Chowdhury, M. H. (1980). Laboratory studies of a low-damage corn-shelling machine. *Transactions of the ASAE*, 23(2), 278-0283.
- Aremu, D. O., Adewumi, I. O., & Ijadunola, J. A. (2015). Design, fabrication and performance evaluation of a motorized maize shelling machine. *Journal of Biology, Agriculture and Healthcare*, 5(5), 154-164.
- Baryeh, E. A. (2002). Physical properties of millet. *Journal of Food Engineering*, 51(1), 39-46.
- Behera, B. K., Dash, S. K., & Das, D. K. (1990). Development and testing of a power-operated wheat thresher. *Agricultural Mechanization in Asia, Africa and Latin America (Japan)*, 21(4), 15-21.
- Bruno Tran, (2017). An expert in post-harvest losses management with the Africa Post-Harvest Losses Information System (APHLIS). Retrieved May 4, 2019 from Myjoy online: <https://www.myjoyonline.com/business/2017/november-17th/ghana-loses-318514-tons-of-maize-to-post-harvest-losses-study.php>
- Chowdhury, M. H., & Buchele, W. F. (1976). Development of a numerical damage index for critical evaluation of mechanical damage of corn. *Transactions of the ASAE*, 19(3), 428.
- Coşkun, M. B., Yalçın, İ., & Özarslan, C. (2006). Physical properties of sweet corn seed (*Zea mays saccharata* Sturt.). *Journal of food engineering*, 74(4), 523-528.
- Darudkar, A. G., Handa, C. C., Darudkar, A. G., & Handa, C. C. (2015). Literature review of corn sheller machine. *International Journal*, 2, 238-240.
- Ghana Corn Domestic Consumption by Year (2018). Retrieved May 4, 2019 from Index mundi: <https://www.indexmundi.com/agriculture/?country=gh&commodity=corn&graph=dome stic-consumption>
- Iwena, O.A., (2002). Essential Agricultural Science for Senior Secondary Schools, Iv Ed., Pp. 12-13
- Joshi, H. C. (1981). Design and selection of thresher parameters and components. *AMA, agricultural mechanization in Asia*.
- Kay, O.E., (1987) Root Crops, Second Edition Revised by E. G. B. Grooding, Crop and Product Digest No. 2, Ii Ed., London: Tropical Development and Research Institute.
- Kepner R. A., Roy B. and Barger E. L. (1972)., Principles of Farm Machinery., 2<sup>nd</sup> Ed., The AvI Publishing Company Inc., Westport, U.S.A. p. 86-88.

ISSN: 2408-7920

Copyright © African Journal of Applied Research

Arca Academic Publisher



- Mady, M. A., (2004). Development and evaluation of a power operated corn sheller. Ismaelia: Soil and Water Dept, Fac. of Agric., Suez Canal University.
- Naveenkumar, D., (2011). Modification and evaluation of power operated maize sheller., " Department of Agricultural Engg., University of Agricultural Science, Bangalore.
- Olanyanju, T. M. A., Adewuyi, S. A. and Omotayo, A. M., (2009). An Assessment of The Status of Small Rice Thresher.
- Sachin, C., (2016). Development and Performance Evaluation of Modified Maize Dehusker Cum sheller, Department of Farm Machinery & Power Engineering Vaugh School of Agriculture Engineering and Technology, Sam Higginbottom Institute of Agriculture, Technology & Sciences.
- Tastra, I. K., (2009). Designing and Testing of Improved Maize Sheller, Vol. 40, Agricultural Mechanization in Asia, Pp. 12- 17, 31.
- Wagami, S. Y., (1979). Design and Fabrication of Prototype of Millet Thresher, Zaria: Unpublished B. Engineering Project Submitted at Dept. Of Agric. Eng. A. B. U.