Performance Evaluation of a Maize Cob Thresher

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Abstract: Threshing is one of the most critical parts of post-harvest operation which affects the quality and quantity of maize production. It could be done manually or mechanically. However, the objective of this study was to evaluate the performance of a maize cob thresher fabricated at National Centre for Agricultural Mechanization (NCAM) Ilorin at three different moisture contents and analyze the result using ANOVA and bar chart as statistical tools. The average values of parameters evaluated at three different stages of moisture content (15.81%, 16.79% and 17.10%) of maize cob are as follow: threshing capacity 754.20, 737.38 and 720.23 kg/h; threshing efficiency 99.73%, 99.63% and 99.16%; cleaning efficiency 89.82%, 89.45% and 88.34%; broken grains ratio 0.84%, 0.79% and 0.70%; time taken 43, 44 and 45 s, respectively. The total amount of maize cob fed into the machine was 9 kg in three replicates for each of the moisture content and the average values of threshed maize of 8.08, 8.05 and 7.95 kg was recovered, respectively. There was significant difference in threshing efficiency, amount of chaffs in the threshed maize and the percentage broken ration. At 17.10% moisture content, the percentage broken grain ratio was minimal. At high moisture content, more force, energy and time is required to thresh certain amount of maize cob. Also, at minimal moisture content less force and energy is required for maximum output. Therefore, considering the previous work on performance evaluation of maize cob thresher, this machine performed satisfactorily and is far better than manual method. The machine is effective, efficient, affordable and available for the small and medium scale farmers in Nigeria.

Key words: Maize cob, thresher, performance evaluation, moisture.

1. Introduction

Maize (*Zea mays* L.) is one of the most important and widely distributed cereals crop in the world after wheat and rice. It is used as staple food for human consumption, feed for animals and serves as industrial raw materials for products like syrup, alcohol, acids, etc. Maize is a rich source of starch and other nutrients beneficial to both human and animal health. Some nutritional values of maize are starch (60.38%-66.31%), protein (10.82%-13.59%), oil content (4.16%-5.76%) and the amount of carbohydrate is between 63.03% and 69.36% [1]. Every country in the world produces maize for different purposes. In year 2010 world ranking, the United States was followed by China in maize production with 177 million metric tons (MMT)

Brazil 56 MMT, Mexico 23 MMT and Argentina 21 MMT [2]. In year 2016, the total maize production in the world is 1,060,107,470 million tons in which Nigeria produced 10.4 million tons [3]. An increase in Nigeria population has greatly increased the consumption of maize either fresh or in milled form by the citizens which made an improved maize production and processing techniques inevitable to increase its production quality and the quantity.

The stages required in maize production include land preparation, planting, fertilizer application, weeding, harvesting, drying, de-husking, threshing, milling, packaging and storage. The processing of agricultural products like maize into quality forms not only prolongs the useful life of these products but also increases the net profit of the farmers through the use of mechanization processing technologies [4]. The quality of maize is determined by the use of suitable threshing techniques. One of the most important processing operations done to bring out the quality of

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maize is threshing and grinding of maize [5]. Maize threshing is a post-harvest operation which could be done either manually or mechanically. The manual method is tedious, time consuming and expensive. Majority of the farmers in Nigeria employ manual method, which has a great implication on their health and income. However, the objective of this work was to carry out performance evaluation of a motorized maize cob thresher at three different moisture contents that is capable of reducing drudgery, time of operation, save cost of production and improve the source of income of Nigeria farmers.

2. Materials and Methods

2.1 Description of the Machine

The thresher consists of hopper, threshing unit, which comprises shaft, threshing drum and beater; sieve, grain delivery chute, cobs and chaffs outlet, blower and the prime mover. The main power source of the machine is the prime mover (R175A diesel engine) with rated speed of 2,600 rpm and power rating of 4.84 kW. The prime mover provides drives through a V-belt connected to the pulley attached to the shaft that drives both the threshing drum attached with set of beaters and the blower. The hopper is a component part where maize is introduced and move into the threshing unit to remove maize from the maize cob after which the separation of maize grain from cobs and chaffs takes place by a sieve. The cleaned maize grains were collected through the grain delivery chute using a collector while the chaffs and cobs were blown off with the aid of blower made of metal blade.

2.2 Evaluation Method

The performance evaluation of the fabricated thresher was carried out at the National Centre for Agricultural Mechanization (NCAM) Ilorin. The variety of maize used in this work is TZLComp1SynW-1. One of the major factors considered in this work was the moisture content of

maize using the procedure developed by International Seed Testing Association (ISTA) [6]. Ten grams (10 g) of sample was taken using electrical weighing balance and oven dried at 130 °C for 4 h. When constant weight was attained, the sample was removed and cooled in the desiccator. The weight of the sample was taken again to determine its final weight. Therefore, 9 kg of maize cob was fed into threshing machine through the hopper and moved directly to a unit where threshing operation was done. The chaffs and other dirty materials were blown off by the blower. The threshed maize grain was collected through the delivery chute using a collector and measured using weighing balance before packaging it in a safe material for further processing. This procedure was done in three replications for each of the three moisture contents of maize grain. Threshing efficiency and some other parameters evaluated were obtained using the equations below [7]:

$$MC = \frac{M_2 - M_3}{M_2 - M_1} \times 100 \quad (1)$$

where MC is the moisture content (%); M_1 is the weight of sample before drying (g); M_2 is weight of sample + container before drying (g); M_3 is weight of sample + container after drying (g).

$$\text{Threshing efficiency} = \frac{M_T - M_U}{M_T} \times 100 \quad (2)$$

where M_T is the total mass of maize fed into the machine; M_U is the mass of the un-threshed maize.

$$\text{Cleaning efficiency (\%)} = \frac{M_C}{M_T} \times 100 \quad (3)$$

where M_C is the mass of cleaned maize delivered by the machine; M_T is the total mass of the maize fed into the machine.

$$\text{Threshing capacity (kg/h)} = \frac{M_T}{T} \times 3600 \quad (4)$$

where M_T is the total mass of the maize fed into the machine; T is the total time taken to thresh maize cob.

$$\text{Grain breakage (\%)} = \frac{M_B}{M_t} \times 100 \quad (5)$$

where M_B is mass of broken maize cob; M_t is the total mass of grain from which the broken maize was

selected.

$$\text{Quantity of chaff in the maize (\%)} = \frac{W_c}{M_t} \times 100 \quad (6)$$

where W_c is the weight of chaff (g); M_t is the total weight of maize (g).

$$\text{Fuel consumption (L/s)} = \frac{q}{T} \quad (7)$$

where q is the amount of fuel (L) consumed by the thresher; T is the time taken (s).

3. Results and Discussion

The pictorial view of the machine was shown in Fig. 1 where testing and evaluation was done.

Table 1 showed the result of the performance evaluation of maize cob thresher at three different stages of moisture contents (15.81%, 16.79% and 17.10%) of maize cob, respectively. This was done to

Fig. 1 Pictorial view of a maize thresher with prime mover.

Table 1 Result for the performance evaluation of a motorized maize cob thresher.

S/N	Moisture contents (%)	Quantity of maize fed into thresher (kg)	Quantity of threshed maize (kg)	Time taken (s)	Threshing capacity (kg/h)	Threshing efficiency (%)	Cleaning efficiency (%)	Broken grains ratio (%)	Quantity of chaff in the threshed maize (%)	Fuel consumption (L/s)
1	15.81	9.00	8.00	45	720.00	99.69	88.90	0.87	2.86	0.0017
		9.00	8.10	42	771.43	99.70	90.00	0.80	2.29	0.0016
		9.00	8.15	42	771.43	99.81	90.56	0.85	2.43	0.0015
	Average	9.00	8.08	43	754.20	99.73	89.82	0.84	2.53	0.0016
2	16.79	9.00	8.00	44	736.36	99.69	88.90	0.80	3.29	0.0016
		9.00	8.05	46	704.35	99.68	89.44	0.78	2.86	0.0017
		9.00	8.10	42	771.43	99.67	90.00	0.80	3.20	0.0015
	Average	9.00	8.05	44	737.38	99.68	89.45	0.79	3.12	0.0016
3	17.10	9.00	8.00	45	720.00	99.14	88.90	0.70	3.37	0.0017
		9.00	7.90	44	736.36	99.22	87.78	0.67	3.49	0.0017
		9.00	7.95	46	704.34	99.12	88.33	0.73	3.63	0.0017
	Average	9.00	7.95	45	720.23	99.16	88.34	0.70	3.50	0.0017

Table 2 ANOVA result for the effect of three different moisture contents on the performance evaluation of a motorized maize thresher at 5% ($p \leq 0.05$) level of significance.

		Sum of squares	df	Mean square	F	Sig.
Threshed maize (kg)	Treatment (moisture content %)	0.029	2	0.014	4.000	0.079
	Error	0.022	6	0.004		
	Total	0.051	8			
Threshing capacity (kg/h)	Treatment (moisture content %)	1,739.473	2	869.737	1.153	0.377
	Error	4,527.509	6	754.585		
	Total	6,266.982	8			
Threshing efficiency (%)	Treatment (moisture content %)	0.602	2	0.301	123.127	0.000
	Error	0.015	6	0.002		
	Total	0.617	8			
Cleaning efficiency (%)	Treatment (moisture content %)	3.572	2	1.786	4.030	0.078
	Error	2.659	6	0.443		
	Total	6.230	8			
Broken grain ratio (%)	Treatment (moisture content %)	0.030	2	0.015	19.600	0.002
	Error	0.005	6	0.001		
	Total	0.035	8			
Quantity chaff in the threshed maize (%)	Treatment (moisture content %)	1.433	2	0.717	13.730	0.006
	Error	0.313	6	0.052		
	Total	1.747	8			
Fuel consumption (L/s)	Treatment (moisture content %)	0.000	2	0.000	1.500	0.296
	Error	0.000	6	0.000		
	Total	0.000	8			

know the suitable amount of moisture required for maize cob to be threshed in order to minimize the percentage grain loss during threshing. However, it was observed that threshing capacity and threshing efficiency of the machine at the moisture content of 15.81%, 16.79% and 17.10% were 754.20 kg/h, 99.73%, 737.38 kg/h, 99.68% and 720.23 kg/h, 99.16%, respectively. The time taken during the evaluation of the machine at 15.81% moisture was less compare to 16.79% and 17.10% moisture, respectively. The percentages of broken grain ratio were 0.84%, 0.79% and 0.70% at moisture content of 15.81%, 16.79% and 17.10% of maize, respectively.

Table 2 showed that there was significant difference in threshing efficiency, amount of chaffs in the threshed maize and the broken grain ratio of the machine under the three different moisture contents of maize grain. In other words, the machine attained its highest threshing efficiency and threshing capacity at 15.81% moisture as shown in Figs. 2 and 3, respectively. At 17.10% moisture content, the

percentage broken grain ratio of the machine was minimal as shown in Fig. 4. This shows that the moisture content of maize cob has a vital role to play in threshing operation.

The performance of this machine was found to be in line with various research studies on the performance evaluation of maize thresher of different capacity. According to a report, a maize shelling machine has a threshing efficiency of 91.29% with an average shelling capacity of 55 kg/h [8]. Also, in another report, a power operated maize Sheller has threshing efficiency and threshing capacity of 98.51% and 402.01 kg/h, respectively [9]. Furthermore, the efficiency of a maize shelling and grinding machine found to be 99.01% at 10% moisture content of maize [10]. Therefore, from this study, it was concluded that the highest threshing capacity and efficiency was obtained at 15.81% moisture content. This shows that the moisture content of maize played an important role in post-harvest operation, precisely in threshing to avoid deterioration of the grain. The higher the moisture

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Fig. 2 Efficiency of the machine. **Fig. 3** Threshing capacity of machine.

Fig. 4 Broken grain ratio against moisture content.

content of maize, the higher the force and energy required to thresh, the lower the moisture contents the easier and faster it is to be threshed.

Therefore, the machine performed satisfactorily under the three different moisture contents (15.81%, 16.79% and 17.10%) of maize cob.

4. Conclusions

The performance evaluation of a motorized maize thresher was carried out satisfactorily. The threshing capacity of the machine was 754.20, 737.38, 720.23 kg/h at 15.81%, 16.79% and 17.10% of maize moisture content, respectively. It was observed that the machine performed better at low moisture content. In other words, there was significant difference in threshing efficiency, quantity of chaffs in threshed maize and the percentage broken grain ratio. The machine has minimal broken grain ratio at 17.10% moisture. The machine is cost effective, efficient and easy to operate and maintain. It reduces the human labor and stress involved in maize threshing and also reduces the time required for threshing operation. The machine is readily available and affordable for small, medium and large scale farmers in Nigeria.

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