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Full Length Research Paper

Performance evaluation of manual cowpea thresher

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Manual cowpea thresher was previously designed and constructed. Its performance evaluation is now reported. Performance test was replicated five times and averages of each trial were taken (50, 100, 150, 200 and 250) kg of two cowpea varieties: indigenous brown (Variety A) and IT97K-499- (SAMPEA -10) white (Variety B). Parameters considered were: Threshing efficiency (Te), Seed damage (Sd) and Mechanical efficiency (Me). The results show that Te, Sd and Me were (91, 6 and 44%), respectively. Issues on cowpea threshing and its improvement were discussed.

Key words: Threshing, cowpea, performance, varieties, manual.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is an annual legume which originated from Africa and is widely grown in Africa, Latin America, South East Asia and the southern United States (Allen and Watts, 1997). Cowpea is used for human consumption and animal fodder and it is rich in protein and is the second economic cash crop in Africa after groundnut (Rachie and Singh, 1985). In Africa, despite the value of cowpea the methods involved in its production, harvesting and threshing are predominantly done manually.

Threshing is done using pestle and mortar or by spreading the dried crop on the floor where it is beaten with a stick (Phillips et al., 2000). Although conventional mechanical threshers such as the Ben–agro paddy thresher, NIAR multi-crop threshers, Alvan Blanch Midget threshers exist (Arnon, 1987), the question is, how suitable are these conventional machines for threshing local crops such as cowpea? Allen and Watts (1998) reported that “a conventional cylinder and concave thresher cannot be used to thresh cowpeas due to the sensitive pericarp of beans and its brittle nature”.

Furthermore, to increase threshing effectiveness, physicomechanical properties of crops have to be considered in the conventional machines before the conceptual, detailed and embodiment designs (Maunde et al., 2005). To thresh cowpea with Alvan Blanch Master multipurpose thresher and reduce mechanical damage, there is the need for pre-threshing before the final threshing of the cowpea with the drum by rubbing action, rather than impact action. This paper discusses the result of performance evaluation of a manual cowpea thresher with the view to modifying it to a motorized one.

MATERIALS AND METHODS

Based on Maunde (2010), Maunde et al. (2010) and Maunde (2008) a manual cowpea thresher with design as shown in Figure 1, was fabricated and tested at the Centre for Equipment, Maintenance and Industrial Training (CEMIT), Federal University of Technology, Yola, Nigerian, Plate 1 shows the picture of the manual cowpea thresher. Two cowpea varieties were used: Indigenous brown (Variety A) and IT97K-499-35 (SAMPEA -10) white (Variety B) for the test at moisture content of pods and seeds of (6.5 and 6.8%), seeds (5.5 and 6.0%) (Maunde et al., 2010; Maunde et al., 2007). The performance test was replicated five times at (50, 100, 150, 200 and 250 kg) of cowpea varieties. There was no provision for cleaning of the cowpea in the manual cowpea thresher, hence the cleaning efficiency and separation losses were not computed. Parameters used for the performance evaluation were as follows (Aiyeleni, 1993):

$$Te = \frac{(Qtc + Qu)}{QtbQtb} \times 100 \quad (1)$$

$$Md = \left(\frac{Qb}{Qtb}\right) \times 100 \quad (2)$$

$$Qc = X1 / Tt \quad (3)$$

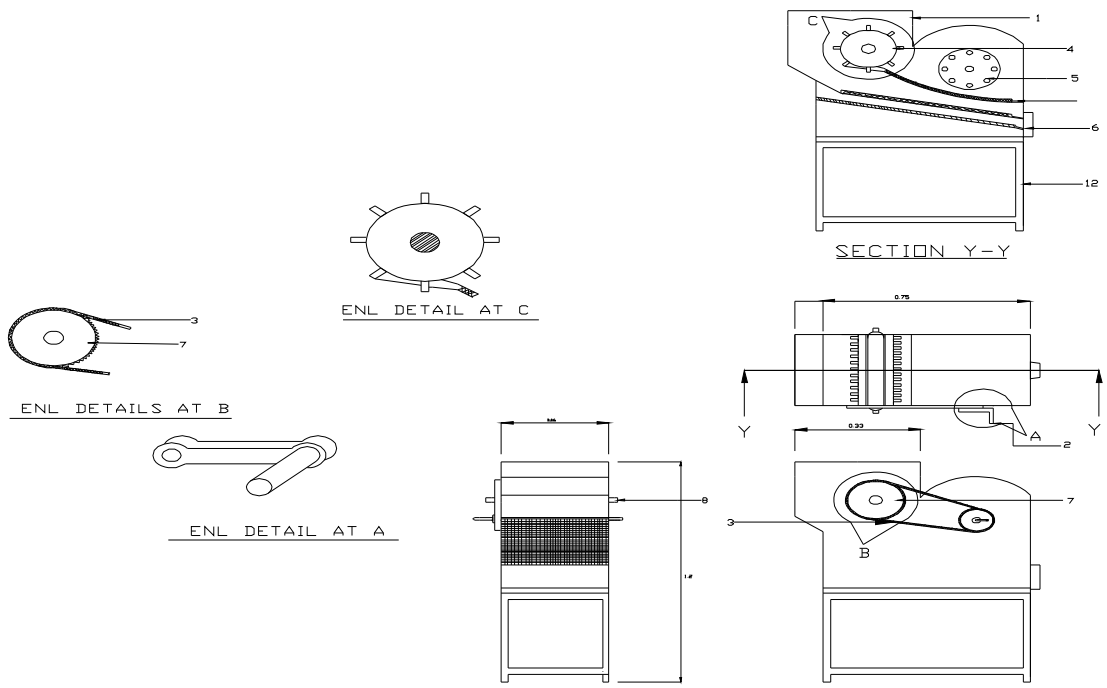

Figure 1. Manual cowpea thresher projected view (Maunde et al., 2010a). Legend: 1. Hopper; 2. Chain and sprocket; 3. Handle; 4. Pre – thresher (Feeder); 5. Secondary drum thresher; 6. Discharge outlet.

Plate 1. Constructed and assembled manual cowpea thresher (Maunde et al., 2010b).

Where: *Tt* = Time taken to thresh cowpea (Min); *Te* = Threshing efficiency (%); *Qtc* = Quantity of threshed and clean cowpea (kg); *Qu* = Weight of unthreshed cowpea after threshing and cleaning (kg); *Qtb* = Total weight of cowpea quantity before threshing (kg); *Md* = Mechanical seed damage (%); *Qb* = Quantity of damaged cowpea after threshing and cleaning (kg); *Qc* = Actual throughput capacity of the manual cowpea thresher (kg/h).

However, Mechanical efficiency (Me), is the ratio of actual output to the design output, thus:

$$Me = \frac{QC}{QD} \quad (4)$$

Where: *Me* = Mechanical efficiency of manual cowpea thresher (%); *QC* = Actual throughput capacity of threshers (kg/h); *QD* = Theoretical designed throughput capacity (kg/h).

Operating principles of the machine

The operation of the machine (Plate 1) is simple, because the handle uses chain and sprocket as its mechanical advantage to reduce force labour in turning the handle. Li et al. (2006) reported that ergonomically the average height of a man is 1 m, hence the height of the manual cowpea thresher considered the total height of 1 m to enable the operator bent free when operating the machine by turning the handle via chain and sprocket (Maunde et al., 2010).

Table 1. Process and performance studies of manual cowpea thresher.

S/N	Varieties	*Parameters considered										
		Qtb (kg)	X1 (kg)	Qu (kg)	Qtc (kg)	X2 (kg)	Qb (kg)	Tt (Min)	Te (%)	Md (%)	QC (kg/hr)	Me (%)
1	XA	150	147	14	130	10	10	130	90	7	68	46
2	XB	150	148	12	127	12	8	125	92	6	71	48
3	XAB	150	146	14	130	11	9	141	91	6	62	42
X		150	147	13	129	33	9	132	91	6.3	65	45

*Terms are defined and calculated with equations (1, 2, 3 and 4) and all values are means of 5 replicates. 148 kg/h designed throughput capacity (QD) of the manual cowpea thresher was captured from Maunde et al. (2010).

A free rotation test was first carried out on the manual thresher to see how it functioned on an empty hopper. Afterward, the thresher was tested again under full load of 10 kg for each (50, 100, 150, 200, 250 kg) of cowpea averaged 150 kg.

RESULTS AND DISCUSSION

The results obtained from the performance evaluation of the manual cowpea thresher are presented in Table 1. From these the following parameters were established in accordance with the terms defined in Equations (1, 2, 3 and 4) aforestated. Total quantity of cowpea before threshing (Qtb), total weight of threshed cowpea before winnowing (X1), weight of unthreshed cowpea after threshing and winnowing (Qu), quantity of threshed and cleaned cowpea (Qtc), total weight of cowpea chaff after winnowing (X2), quantity of damaged cowpea after threshing and cleaning (Qb), time taken to thresh cowpea (Tt), threshing efficiency (Te), mechanical seed damage (Md), actual throughput capacity of the thresher (QC) and thresher mechanical efficiency (Me). To thresh the cowpea from its pods, after loading into the hopper, the applied force on the handle must exceed the force required to turn the sprocket via the feeder before the drum and concave does the secondary threshing as seen in Figure 1 and Plate 1. For effective performance, the thresher was loaded two third volume of the hopper, since filling the hopper will amount to high labour requirement and increase in time of operation.

Average of 150 kg cowpea varieties A and B was used for the test. The cowpea thresher only does the threshing, there was no provision for the cleaning Average summary of varieties A and B for Qtb , X1 , Qu, Qtc, X2, Qb, Tt, Te, Md , Qc, and Me was found to be 150, 147, 13, 129, 33, 9 kg , 132 min, 91%, 6.3% , 65 kg/h and 45% respectively. Threshing effectiveness, seeds damage, throughput capacity of Kananado, Borno Brown and Aloka local were found (85.9, 84.6, 84.1%), (1.8, 2.3, 1.9%) and (95.4, 93.5, 92.8 kg/h) respectively (Dauda, 2001). Throughput capacity of a manual peddle cowpea thresher was found to be 50 kg/h (Bello, 1997), which was less than 65 kg/h, the present manual hand cowpea thresher. Both results show that the manual thresher can only thresh cowpea at a time and do the cleaning thereafter manually by winnowing. The 6.3% mechanical seed damage of the thresher in question compares favorably with the postulation by Allen and Watts (1997), that depending on the amount of cowpea threshed, the amount of broken cowpea should not exceed 15% of the total weight of threshed cowpea. However, moisture content state and impact on the cowpea pods during threshing are paramount in determining crop mechanical damage (Allen and Watts, 1997; Dauda, 2001).

Precautions

To keep the machine in good operating condition at all times, measures have been enumerated below which when adhered to will prolong the service life and ensure smooth operation of the thresher: The bearings should be greased from time to time, the thresher should be cleaned and sun dried after every operation, the thresher should be painted periodically after at least six months of consistent use to prevent deterioration of its metal components.

CONCLUSION AND RECOMMENDATIONS

Performance evaluation of the manual cowpea thresher was conducted. The average mechanical efficiency, threshing efficiency and throughput capacity are 46%, 90% and 67 kg/h respectively. Hence, the thresher was found to meet the previous design objectives. Based on the throughput capacity of the thresher, the thresher was estimated N 33, 800.00 (Thirty three thousand eight hundred naira only). Approximately, an equivalent $ 5.4 million (five point four million US Dollars) as at 15th October, 2011. It is recommended that the thresher should be designed in various sizes to increase its efficiency and also to make it more affordable to the peasant farmers. Further work should look into the

possibility of motorizing this manual cowpea thresher and making a provision for cleaning, separation and conveying.

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