



Full Length Research Article

DESIGN AND CONSTRUCTION OF AFRICAN YAM BEAN THRESHER

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ABSTRACT

African yam bean is a legume that has not been sufficiently utilized. In order to encourage large scale cultivation of this crop, a threshing machine was designed, fabricated and evaluated. The materials for the machine parts were carefully selected from locally available materials putting into consideration factors such as strength, ergonomics, quality of grain and cost using relevant engineering principles. The machine was locally fabricated having a capacity 38.96kg/hr. The results of evaluation indicated a mean threshing efficiency of 99.5%. The damaged grains were 11.41% of the threshed grains and a cleaning efficiency of 95.42% was recorded. The efficiency of the thresher was observed to vary with the moisture content of the grain. This variation persist until the optimum moisture content is reached.

Key words:

INTRODUCTION

Threshing in Retrospect

As a result of increasing and diverse use of grain crops, it is necessary to intensify efforts in research work that will encourage large scale post harvest operations of grains, especially threshing and shelling. Threshing is the separation of seeds or grains from the pods or heads of crops. The earliest method of threshing was to beat the grains out with sticks. This arduous task was first simplified by the ancient Egyptians who introduced a method whereby the grain heads are spread out on a hard surface or ground and oxen are driven over them to trample out the grains from the heads. In Nigeria, threshing is done traditionally by placing the harvested African yam bean on the floor of mud or concrete and beaten with a stick or flailed. Other methods include the use of mortar and pestle to remove the seeds. These methods of threshing, however, are not convenient enough since the output is very low, sometimes contaminated, time consuming and requires high labor.

In recent times, attempts have been made to solve these problems in Nigeria by the developing both manually and mechanically operated threshing machines. Threshing machines for other grain have been designed by other researchers such as coffee (Ogunlade *et al.*, 2014), okra (Ajav and Adejumo, 2005), black seed (Afify *et al.*, 2007), maize (Abdulkadir *et al.*, 2009 and Nwakaire *et al.*, 2011), maize (Olumuyiwa *et al.*, 2014) etc. Dauda, (2001) designed, constructed and evaluated the performances of a manually

operated cowpea thresher for small scale farmers in with threshing efficiency of 85.96%, 84.6% and 84.1%, and respectively and winnowing efficiencies at 372rpm fan speed were 92.75%, 92.5% and 92.35%. A medium scale thresher cleaner with conveyor belt, fan and cleaning unit for grain legume with threshing efficiency of 67.5 – 97.7% and cleaning efficiency of 98 – 100% was designed and fabricated by Adewunmi *et al.*, (2007). Irtwange, (2009) designed, fabricated and evaluated the performance of a motorized cowpea thresher which give a threshing efficiency of 96.29%.

Threshing efficiency usually varies for the various species of any particular crop just as crop and machine parameters has to be adjusted to suit particular specie. Olaoye, (2011) reported the IT86D-719 variety could be threshed at threshing efficiency of 95%, at the cylinder speed of 100 rpm and at moisture content 12% wb, and The IT84S-2246-4 variety, threshing is feasible at threshing efficiency of 97%, at cylinder speed of 100 rpm and moisture content of 11% wb. The manual method of African Yam Bean threshing is arduous, laborious, time consuming, producing poor quality grains, low productivity, with much wastage of grains.

This machine will serve the rural or small scale farmers as an alternative to traditional method of threshing. The mechanical method of threshing has the advantage of being labour free and time saving, in addition, it increases the quality of production. The objective of this project is to design and fabricate an African Yam Bean thresher and to evaluate the performance of the thresher.

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MATERIALS AND METHODS

Material Selection

The materials used were obtained locally from Modern market in Makurdi, Benue State. These materials were selected based on strength, availability, durability and cost to prevent machine damage, ease construction work and maintenance and reduce the cost of machine so as to make it affordable hence, scrap mild steel angle iron was used for the frame and mild steel sheet for the threshing chamber. The shafts were also mild steel rods.

Design Consideration and Analysis

The pre-design stage included measurement of the physical and engineering properties of the crop to determine appropriate design parameters for the threshing operation. The threshing component was designed using relevant engineering principles and theories. The design concept involves the use of impact forces of mild steel rod beaters against steel plate with sufficient power requirement. The design considerations included; economy and ergonomics, machine efficiency and product quality, simple operational and maintenance requirements to meet the need of local farmers, detachability for easy transportation and economic use of power.

Description of the thresher parts

The Hopper

Available information on the pod length, width, thickness and angle of repose was used in the design of the hopper. The hopper serves as a feeding unit through which the AYB pods will be poured into the threshing chamber. It is shaped as a frustum and has a height of 200mm.

The Drum

The drum is constructed of 16-gauge steel sheets rolled into a perfect cylinder of 200mm diameter and 380mm length. 69 Iron rods of 10mm diameter and 40mm heights were welded in four rows to the body of the cylinder to serve as the spikes. The drum help to spike the AYB pods against the concave in order to separate the seeds.

The Shaft

The shaft with a diameter of 25mm and a length of 622mm passes through the threshing drum and carries it. It also carries two bearings (one at each end) and one pulley for power transmission from the electric motor to the threshing unit and from the threshing unit to the fan in the cleaning unit.

Concave

The drum housing is also constructed of 16-gauge metal sheet rolled into a cylinder of 320mm diameter and 460mm length. Slots were made at both ends of the concave to allow for passage of the shaft and to provide for easy movement of the drum.

The Screens

There machine was fitted with two screens; the threshing screen and a sorting screen. The threshing screen is made of

16-gauge metal sheet placed 20mm below the threshing cylinder. Perforations of 10mm width and 50mm length were made along the length of the screen. The sorting screen was made of wire gauze with mesh size of 10mm. It was placed below the first screen and the air outlet from the fan. This screen helps to sort the seeds from the broken pods that may escape the air stream of the fan.

The Fan

A fan was incorporated into the machine for blowing chaff. It is a separating unit (cleaning unit) and blows the chaff out through the chaff shut as they fall out of the drum (threshing unit) through the threshing screen. The design of the fan was based on the aerodynamic properties of the chaff and the seed. The air pressure was such that it was enough to blow out the chaff, but not strong enough to carry the seeds along.

RESULTS AND DISCUSSION

The performance test result carried out on the African Yam Bean thresher using African yam Bean at 11%-13% moisture content range and engine speed of 467rpm is shown in Table 1.

Where;

W_1 is threshed AYB, W_2 is threshed but damaged AYB, W_3 is threshed and undamaged AYB, W_4 is Weight of contaminants in the grain, W_5 is Weight of grains in the Chaff outlet, T_0 is threshing efficiency, P_d is percentage damage, P_t is Percentage threshed and undamaged, η is Cleaning efficiency and C_1 is Cleaning loss.



Fig.1. African Yam bean Thresher

Machine Operation

The African yam bean thresher shown in Figure 1 consists of 3 main essential units which are: feeding unit, threshing unit and Wincrowing Unit. The feeding unit provides an opening through which the African yam bean is introduced into the machine for threshing. It is located directly above the spike tooth cylinder and is welded to the cylinder upper housing. The hopper spreads through the whole length of the cylinder and has an opening into the threshing unit, this facilitates easy feeding.

Table 1. Test result carried out on the African yam bean thresher using African yam bean at 11-13% moisture content

Test M.C (%)	W ₁ (g)	W ₂ (g)	W ₃ (g)	W ₄ (g)	W ₅ (g)	T ₀ (%)	P _d (%)	P _t (%)	η (%)	C _i (%)
10%	1259.0	174.32	1084.68	68.0	31.0	100	13.85	86.15	94.60	2.40
11%	1092.5	82.14	1009.86	55.5	33.1	100	7.51	92.44	94.92	2.90
12%	1340.7	171.40	1168.60	51.1	24.0	99.76	12.79	87.16	96.19	1.76
13%	1372.4	157.69	1214.70	55.6	35.8	98.06	11.49	88.50	95.95	2.54
Average	1266.2	146.39	1119.46	53.3	30.9	99.50	11.41	88.56	95.42	2.40
Variance	15684.0	1887.01	8235.91	6.8	24.5	0.88	7.69	7.59	0.92	0.23
Standard Deviation	125.2	43.44	90.75	2.6	5.05	0.94	2.77	2.75	0.96	0.48

The threshing unit consists of a spike-toothed cylinder of length 380mm and diameter of 200mm on which is attached cylindrical spikes of 10mm diameter 4mm length. The spikes beat the pods against the slit screen (slit dimensions; 10mm x 5mm) located 20mm below it, thus causing threshing. The separating section consists of a chaff outlet, a screen and a centrifugal fan. As the threshed seeds and chaff falls through the first screen, they are sorted out at the second screen which is gauze of 10mm mesh size and this allows only the threshed seeds to pass to the seed delivery chute. The air from the fan which is channeled through this chamber to the chaff outlet carries with it, the loose chaff. The thresher throughput for the African yam bean was an average of 38.96kg/hr,

Performance Evaluation

The 300mm diameter, centrifugal type fan is located below the screen and is positive displacement fan designed to blow the chaff material that falls through the screen slits. The motor used was 1hp while cylinder and fan shaft diameters of 25 mm were selected. To provide the recommended cylinder speed of 467rpm and fan speed of 1166 rpm, cylinder pulley of 225mm and fan and motor pulleys of 75mm were selected. The performance test result carried out on the African yam bean thresher is shown in Table 1. The results indicated a mean threshing efficiency of 99.5%. The damaged grains was 11.41% of the threshed grains. This may be due to the crop or machine variables. A cleaning efficiency of 95.42% was observed as a result of the combined action of the fan and the sorting screen. The thresher throughput for the African yam bean was an average of 38.96kg/hr, this low throughput may have been due to the fact that the hopper was not filled before operation, but was fed during operation in small batches as bulk feeding was not favorable for the 1 hp motor used.

Variations of Machine Efficiency with Grain Moisture Content

The moisture content of the grain was varied between 10%-13% for the testing of the machine. This is to determine the optimum moisture content in which the most efficient threshing will be obtained. The result of the test indicated that the best threshing efficiency of 100% was obtained at a moisture content of 10- 11%. The threshing efficiency reduces as the moisture content increases but better cleaning efficiency is obtained at higher moisture content. A cleaning efficiency of 96.19% was obtained at a moisture content of 12% which is the optimum efficiency obtained.

Conclusion

An African yam bean thresher with a capacity of 38.96kg/hr was designed, fabricated and its performance evaluated. The threshing efficiency was obtained as 99.5% at an engine speed of 467rpm and moisture content of 10-13% db.

The threshing efficiency was seen to vary with the moisture content of the pod. The cleaning efficiency of the machine was obtained as 96.19% at a moisture content of 12%.

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