Performance Evaluation of a Tractor Mounted Groundnuts Harvester

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Abstract
The performance of an existing tractor mounted groundnut harvester was evaluated at different levels of machine speed (2 km/hr, 3 km/hr, 4 km/hr and 5 km/hr) and a constant penetration depth of 10 cm. Harvesting efficiency decreased with increasing speed while percentage damage increased with increasing speed. The highest harvesting efficiency (75.3 %) was obtained for 2 km/hr operation speed and the lowest harvesting efficiency (63.7%) was obtained at 5 km/hr operation speed. The highest percentage damage (34.2 %) was obtained at 5 km/hr machine speed and the least percentage damage (17.1 %) was obtained at 2 km/hr speed. Analysis of variance showed that machine speed made significant effects ($p \leq 0.05$) on the parameters evaluated and the separation of means using F-LSD showed significant difference at. $p \leq 0.05$
Keywords: Performance, groundnuts, tractor mounted, harvester.

INTRODUCTION

Groundnut also called peanuts or earthnuts *(Arachis Hypogaea* of the *Leguminocae* family) is grown as an oil seed and grain legume crop. It is a major cash crop and is widely grown in tropical and sub-tropical regions of the world for direct use as food, oil and for high protein meal (Onwueme, 1991).

Groundnut originated in the Southern Bolivia/North West Argentina region in South America and is currently cultivated in 108 countries of the world. Asia has 43.6% area and produces 71.7% of the world groundnut production followed by Africa with 31.5% area and 18.6% production, and North Central America with 3.7% area and 7.5% production. Important groundnut producing countries are China, Indonesia, Myanmar, Thailand, and Vietnam in Asia; Nigeria, Senegal, Sudan, Zaire, Chad, Uganda, Cote-Devoior, Mali, Burkina Faso, Guinea, Mozambique and Cameroon in Africa; Argentina and Brazil in South America, USA and Mexico in North America (Weiss, 2000). Nigeria produces 4% total groundnut in West Africa (Oke, 1979).

The history of commercial production of groundnut in Nigeria dates back to 1912 when farmers were encouraged by high economic returns from groundnuts. At the end of each harvesting season; agents went to the hinter lands to collect the produce, such that farmers needed not to worry about conveying their produce to markets. The collected produce were then transported by railways to Lagos for export (Adenwumi, 1986). Groundnut is widely cultivated in the northern part of Nigeria and Kano was the hub for groundnut trading activities, and this was evident in the presence of groundnut pyramids (Adenwumi, 1986)

Groundnuts are eaten raw, roasted or pounded for sauce, making of margarine and cooking oil. The residues left after oil extraction may be fed to livestock, while best quality nuts are used in making confectionary and are an important source of protein in many countries (MacDonald and Low, 1984).

Groundnut does well on fertile sandy loamy soils, thoroughly prepared to a depth of 25-30 cm (MacDonald and Low, 1984). The most common plating practice of groundnut in Nigeria is to plant on ridges about 90 cm apart, with two to three kernels per hole at inter-row spacing of about 30 cm for runner type and 15cm for bunch type in heavy soils and 6-8 cm for lighter soils (Onwueme, 1991).

Harvesting of groundnut is the most important and labour intensive operation in groundnut cultivation. The present practice of manual harvesting consumes a huge amount of labour to the magnitude of 84 man hour/hectare (Padmanathan et al., 2006).

Manual method is the process of harvesting groundnut manually by hand using cheap human labour. This is achieved by holding the flower end of the plant and pulling to remove fully matured groundnut pods attached on the stem from the ground. Groundnut is harvested and exposed to air and sunlight for proper drying. Manual method of harvesting is very tedious and time consuming and is best utilized for small-scale farming.

Mechanical method is the use of machines to harvest groundnuts. This reduces labour requirements, time of harvest per workday, and is faster. This type of method is best used for commercial or large scale farming.

Harvesting too early or lately results in substantial loss in yield. Harvesting early causes the shriveling of large proportion of the kernels. Immature pods lose about half of their weight during curing and develop undesirable flavors. Harvesting late, meets with pods that are already germinating and the process of germination is highly rapid (Onwueme, 1991).

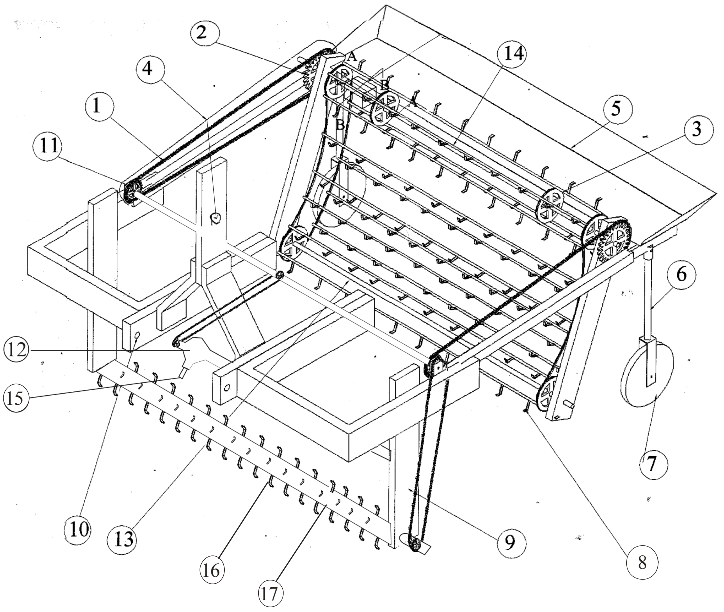
Many and varied groundnut harvesting equipment have been designed and produced worldwide, ranging from simple hand tools to complicated harvester. All these have been in recognition of the need to mechanize the harvesting operation and also to reduce losses and increase profit.

A survey of groundnut harvesting machines and implements has revealed implements with high mechanical advantage that are either OX-drawn or tractor mounted. While some of these implements simply dig up and loosen the soil from the plant, leaving the removal of the crop from the soil to manual labour, others remove the crop from the soil and leave gathering only to manual labour. Others still go to the extent of separating the pods from the haulm, leaving the pods in an attached receiver. The groundnut combined harvester does all these, and delivers the pods to a following trailer, or places the pods in bags and drops the bags on the field to be collected.

MATERIALS AND METHODS

Description of the Groundnut Harvester

The principal components of the tractor mounted groundnut harvester are the frame, Soil loosening tool , Tool (blade), Pick up conveying mechanism, PTO Drive Mechanism, Chain and Sprockets, Land wheel and Gathering windrower. The soil engaging tool is made of 50 mm thick 100 mm x 180 mm length straight mild steel blade capable of engaging the soil and harvesting groundnuts. The tool at 15^0 rake angle is fixed to the main frame through shanks of both sides. The pickup conveying mechanism of length 1200 mm is made of two 600 mm endless ship chains spaced 180 mm apart. At the rear, a gatherer windrower is responsible for windrowing the groundnut crops at soil moisture levels of 8-15%. The harvester has an overall dimension of 2050 x 2100 x 1150 mm. The weight of the machine is 300 kg and is capable of harvesting 2 hectares per day. Figure 1 is the isometric drawing of the tractor mounted groundnuts harvester and figure 2 is the orthographic drawing of the tractor mounted groundnuts harvester.



17.	Roller Shaft	Mild steel	90mm DIA	1
16.	Loosening Tool	Mild steel	100mm LONG	64
15.	PTO Shaft	Mild steel	6 Splines	1
14.	Chain Sprocket	Mild steel	1800mm DIA	1
13.	Picker Shaft	Mild steel	1200mm DIA	1
12.	Bevel (Pinion) gear	Mild steel	Standard	1
11.	Driven Sprocket	Mild steel	20mm LONG	2
10.	Linkage Point	Mild steel	Standard	3
9.	Frame	Mild steel	90x90x1.5DIA	1
8.	Picker	Mild steel	180mm LONG	192
7.	Land Wheel	Mild steel	150mm DIA	2
6.	Land Wheel Shaft	Mild steel	10mm thick 30.1mm	2
5.	Windrower	Mild steel	10mm Thick	2
4.	Pin hole (coupling point)	Mild steel	20mm hole DIA	3
3.	Picker wheel	Mild steel	100mm DIA	2
2.	Driver Sprocket	Mild steel	10mm DIA	2
1.	Chain	Mild steel	600mm LONG	2
Part No.	**Item**	**Material**	**Dimension**	**Qty**

Fig. 1: Isometric Drawing of the Tractor Mounted Groundnut Harvester

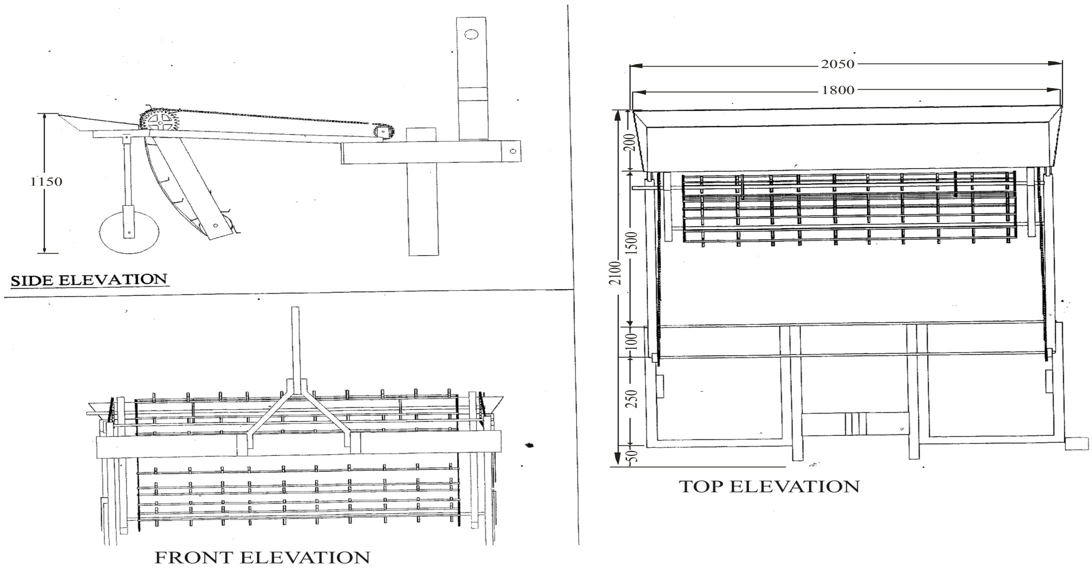


Fig. 2: Orthographic Drawing of the Tractor Mounted Groundnut Harvester

Determination of Machine Parameter

A four-wheel-drive Mersey Ferguson MF 375E tractor with Gross weight of 2,200 kg, Overall width of 1,651 mm, Overall length of 3,542 mm and Ground distance of 338 mm was used to perform the experiments. The machine parameter determined was the tractor speed.

Determination of Tractor Speed

Four treatments of the tractor speeds chosen were 2, 3, 4 and 5 km/hr corresponding to S_1, S_2, S_3 and S_4 respectively. Before the actual experiments starts, the various revolutions per minute of the engine read off from the speedometer that corresponds to the chosen tractor forward speeds were determined.

Plot Design and Layout

The experimental plot is 21 m long and 18 m wide. The field experiments were laid out as 4 x 1 row-column designs replicated three times. Seeds were planted on flat surface at 3-4 cm spacing placed at about 15 cm depth, with 2-3 seeds per hole. The trials were hand-weeded twice at four weeks and seven weeks after planting.

Experimental procedure

One factor, machine speed was considered for this study and was evaluated at four levels, namely 2 km/hr, 3 km/hr, 4 km/hr and 5 km/hr. The groundnut harvester was tested at a constant operation depth of 10 cm with four different speeds on a flat field containing groundnut plants. At each speed, the weight of the quantity of groundnuts harvested was measured. The performance indices were evaluated as follows:

Harvesting Efficiency

Harvesting efficiency of the machine was determined using the equation;

$$E_h = \frac{W_h}{W_h + W_{uh}} \times 100$$

Where:

E_h = Harvesting efficiency in percent.
W_h = Weight of harvested groundnut per plot.
W_{uh} = Weight of un-harvested groundnut per plot.

Percentage Damage

Percentage of damage groundnut was determined using the equation;

$$P_d = \frac{W_d}{W_h} \times 100$$ (Padmanathan, et al 2006)

Where:

P_d = percentage damage of groundnut per plot,
W_d = weight of damage groundnut per plot,

W_h = weight of harvested groundnut per plot.

Effective field capacity (FC_E)

$$FC_E = W_a \times E_w \times \frac{10^4}{3600} \ (ha/hr)$$

Where:
FC_E = Effective field Capacity (ha/hr)
W_a = Effective harvesting width (m)
E_h = Harvesting efficiency (%)

Theoretical field capacity
Theoretical field capacity (FC_T) is calculated from the *mean* values of working width and working speed

$$FC_T = working\ width \times mean\ speed$$

Experimental Design
The experimental design for the statistical analysis follows a one-treatment effect (machine speed) in a Randomized Complete Block Design (RCBD) with three observations (replications) per experimental unit. All data collected were subjected to analysis of variance (ANOVA) to test for significant effects at 95 % confidence limit using the procedure recommended by Steel and Torrie (1980). When significant difference was observed, treatment means were separated using the F-LSD.

RESULTS AND DISCUSSIONS
Results
The Analysis of variance (ANOVA) at $P \leq 0.05$ of the effect of machine speed on the harvesting efficiency (%) is presented in Table 1 while the Analysis of variance (ANOVA) at $P \leq 0.05$ of the effect of machine speed on the percentage damage (%) is presented in Table 2 and their Means using F-LSD is presented in Table 3. Figure 4 shows the effect of machine speed on the mean harvesting efficiency (%) and percentage damage (%).

TABLE 1: ANALYSIS OF VARIANCE OF THE EFFECT OF MACHINE SPEED ON HARVESTING EFFICIENCY (%)

Sources of Variation	Df	SS	MS	Observed F	Required F (5%)
Blocks	2	2.56	1.28	1.04^{ns}	5.14
Treatment	3	225.26	75.09	61.05^{*}	4.76
Error	6	7.38	1.23		
Total	11	235.20			

* - significant; ^{ns} - not significant

TABLE 2: ANALYSIS OF VARIANCE OF THE EFFECT OF MACHINE SPEED ON PERCENTAGE DAMAGE (%)

Sources of Variation	Df	SS	MS	Observed F	Required F (5%)
Blocks	2	3.77	1.89	1.35^{ns}	5.14
Treatment	3	465.66	155.22	110.87^{*}	4.76
Error	6	8.40	1.40		
Total	11	477.83			

* - significant; ^{ns} - not significant

TABLE 3: EFFECT OF MACHINE SPEED ON THE MEAN HARVESTING EFFICIENCY (%) AND PERCENTAGE DAMAGE (%)

Parameter	Machine Speed (km/hr)			
	2	3	4	5
Harvesting Efficiency	75.3^{a}	70.7^{b}	66.8^{c}	63.7^{d}
Percentage Damage	17.1^{a}	23.2^{b}	27.7^{c}	34.2^{d}

Means having the same letter in the same row are not statistically different from each other at $P \leq 0.05$ using F-LSD.

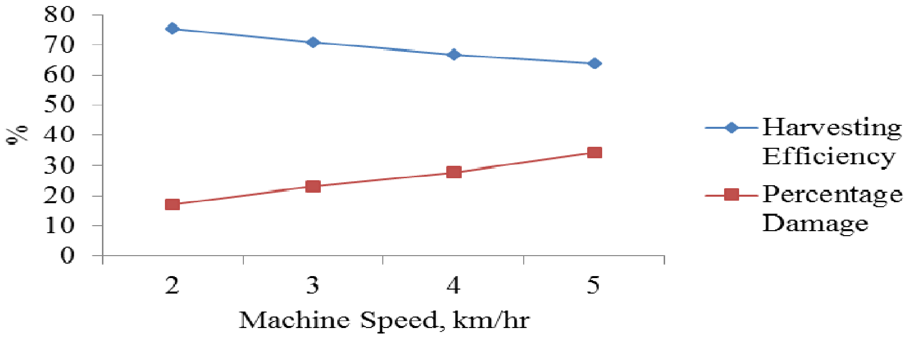


Fig. 3: The effect of machine speed on the mean harvesting efficiency (%) and percentage damage (%)

Discussions

The Analysis of variance (ANOVA) of the effect of operation speed on harvesting efficiency and percentage damage at $P \leq 0.05$ are presented in tables 1 and 2 respectively. Table 3 shows effect of machine speed on the mean harvesting efficiency (%) and percentage damage (%) while figure 3 shows the effect of operation speed on the mean harvesting efficiency (%) and percentage damage (%).

From the Analysis of variance (ANOVA), there was a significant difference in the operation speed on the parameters evaluated and the separation of means using F-LSD showed significant difference at $p \leq 0.05$. It was observed from table 3 that harvesting efficiency decreased with increasing speed while percentage damage increased with increasing speed. The highest harvesting efficiency of 75.3 % was obtained at 2 km/hr operation speed and the lowest harvesting efficiency of 63.7% was obtained at 5 km/hr operation speed. The highest percentage damage of 34.2 % was obtained at 5 km/hr machine speed and the least percentage damage of 17.1 % was obtained at 2 km/hr speed.

Conclusion

The harvester had good performance on groundnuts planted on flat land. The soil loosening tool and the conveying mechanism had impressive performances.

Results of the performance evaluation of the machine showed that operation speed had negative association with harvesting efficiency. Harvesting efficiency decreased with increasing speed while percentage damage increased with increasing speed. Analysis of variance showed that machine speed made significant effects ($p \leq 0.05$) on the parameters evaluated and the separation of means using F-LSD showed significant difference at $p \leq 0.05$.

Recommendations

i. The groundnut harvester should be operated at a speed of 2 Km/hr and at a constant depth of 10cm for optimum performance.
ii. Separation of the soil from harvested groundnuts needs to be enhanced by introducing some form of vibrating mechanism to shake of the soil during operation.
iii. Chain covers should be provided at the chain drive to avoid soil sticking on them during harvesting operation.

REFERENCES

Adenwumi, T. (1986). Local Technology for African Farms. AFP Publishers. PP. 25-50

MacDonald I. and J. Low (1984). Tropical Field Crops. Published by Evans Brothers Ltd. London Wain UE pp. 35-36

Oke, C. (1979). Farm Mechanization. Longman Publishing UK London. PP. 18-39

Onwueme, J.C. (1991). Field Crop Production in the Tropical Africa ED. The Netherlands CTA Publishing pp. 250-265

Padmanathan, P.K., K. Kathivel; R. Manian and V.M. Duraisamy (2006). Design, Development and Evaluation of Tractor Operated Groundnut Combine Harvester. Dept. of Farm Machinery Agricultural Engineering, College and Research Institute Tamil Nadu Agricultural University, Coimbatore India. Journal of Applied Research. 2(12): 1338-1341

Steel, R.G. and Torrie, J.H. (1980): Principles and Procedures of Statistics. NewYork: McGraw-Hill Book company.

Weiss, (2000). World Geography of the Peanuts. Macmillan Publisher, London. PP. 45-50