NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS (NIAE)

A DIVISION OF THE NIGERIAN SOCIETY OF ENGINEERS

PROCEEDINGS OF THE 18TH INTERNATIONAL CONFERENCE AND 38TH ANNUAL GENERAL MEETING

UMUDIKE 2017

THEME:

DYNAMICS OF AGRICULTURAL ENGINEERING FOR FOOD AND AGRO-INDUSTRIAL RAW MATERIALS PRODUCTION FOR ECONOMIC RECOVERY IN NIGERIA

TUESDAY 3RD- FRIDAY 6TH OCTOBER, 2017

VENUE:

Senator Anyim Pius Auditorium,
Michael Okpara University Of Agriculture, Umudike

EDITED BY:

ENGR. PROF. I.E. AHANEKU
ENGR. DR. M. C. NDUKWU
ENGR. O.O. ONU
ENGR. G. INEKWE

TABLE OF CONTENT

LEAD PAPER PRESENTERS

Proceedings of 18th International Conference and 38th Annual General Meeting of the Nigerian Institution of Agricultural Engineers (NIAE), Umudike, 2017

Evaluation of an Animal Drawn Groundnut Digger for Improved Productivity of Groundnut Farmers in the Semi-Arid West Africa

*A. Adinoyi[1], M. L. Attanda[2], H. A. Ajeigbe[1] and A.Kunihya[1]

[1]*International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Kano – Nigeria*
[2]*Department of Agricultural and Environmental Engineering, Bayero University (BUK), Kano – Nigeria*
***Corresponding Author:** a.adinoyi@cgiar.org*

***Abstract:** Groundnut cultivation in the Semi-Arid West Africa is characterized by high labour demand especially during land preparation and digging of matured pod (harvesting). While implements are available for mechanization of land preparation, the same is not true for harvesting. A field experiment was conducted to measure the operational performance and the effectiveness of an animal drawn groundnut digger on pod and fodder yields and pod loss of two groundnut varieties. Results showed highly significant difference ($P \leq 0.05$) between the varieties with respect to pod loss, pod and fodder yields. Soil moisture contents had significant effect on pod loss, while cutting depths had significant effects on pod yield and pod loss. There were significant varieties by cutting depth interaction for fodder yield while significant interaction was observed among groundnut varieties, soil moisture contents and implement cutting depths on pod yield. With reduction in soil moisture content from 12.4% to 5.9%, pod loss increased from 112.285 kg/ha to 172.28 kg/ha. Results further revealed significantly higher pod loss of 202 kg/ha obtained during the manual digging compare with 78.13 kg/ha and 146.56 kg/ha when operating the digger at 15 cm and 10 cm cutting depths, respectively. The animal drawn groundnut digger is recommended for up-scaling among small and medium scale groundnut farmers in the Semi-Arid west Africa, while effort should be made to design a tractor drawn one for the large scale farmers for the reduction in drudgery associated with groundnut harvesting, reduction in pod loss and increased groundnut productivities.*

Keywords: Cutting depth, groundnut digger, moisture content, Fodder, Pod

Introduction

Agricultural power sources are categorized mainly into three (human, animal and motorized power). In the rural areas of developing countries like Nigeria, farmers use simple implements and tools utilizing human and animal power, consequently their production is low (Moayad *et al.*, 2013). The uses of large machinery are expensive for small-scale agriculture which may not be suitable solution for smallholder farmers (Miles, 1982). The introduction of animal–drawn implements as intermediate technology for smallholder farmers is necessary, especially for crucial operations such as land preparation, weeding and harvesting. Animal drawn implements as compared to manual tools have positively affected crop production factors through improving field efficiency and capacity, increasing harvested yield and reducing costs of production (Dahab and Hamad, 2003).

The challenges of groundnut harvesting in less-developed regions are commonly caused by drudgery of lifting plants from the ground. This task is most mechanized operation in developed countries and replaces hard manual labour of digging groundnut (Nautiyal, 2002). Previous studies have shown that it takes 120 to 150 man-hour to harvest an hectare of groundnut field, while manual harvesting can also cause depletion of soil fertility due to removal of the complete root system along with nitrogenous nodules(Ademiluyi *et al.*, 2011). The mechanical harvesting of groundnut has advantage of reducing the cost and labour required and is conducive to better soil fertility as the blade of the digging implement cuts through the root below the pod zone and leaves the remaining root system in the soil. The search for more efficient, cost-effective ways of harvesting groundnut is necessary because of the extreme labour intensity of this task. Nautiyal, (2002) reported that up to 40 percent of the total labour required to grow groundnut is expended on harvesting operation and that at peak harvest periods, labour shortages often occur leading to higher costs of production or reduction in yields. The present study evaluate operational performance of an animal-drawn groundnut digger and its effect on pod loss, harvested pod and fodder yields of two selected groundnut varieties.

Materials and Methods

An animal drawn groundnut digger with 0.25 ha/hr effective field capacity, pulled by two work bulls was evaluated on a sandy loamy soil of the Teaching and Research Farm, Faculty of Agriculture, Bayero University Kano,(11° 973″ N, 8° 415′ E444m). The experiment had 2 x 2 x 3 factorial treatments arranged in a randomized complete block design (RCBD) with three replications. The treatments used were: two soil cutting depths (10cm and 15cm) with

control(digging manually using hoe), two groundnut varieties (SAMNUT 23 and SAMNUT 26) and 2 soil moisture content (12.4% and 5.9 or 9.5%). Soil moisture content was determined in order to assess the effect of percentage moisture of the soil during harvest at groundnut maturity. The soil moisture content was determined as described by FAO (1994). This procedure was repeated after delay of harvesting for 10 days to vary the soil moisture content. The digger cutting edge was designed to be adjusted by means of calibration made on the two depth control ground wheels. Five measurements for each graduation were taken from five run conducted on each of the graduation to verify the set depth of operation for each treatment. A meter rule was used to determine the vertical distance between the soil surface and depth of cut as the blade cuts through the ridge. The averages were recorded as the depth of operation.

Data Collection

The digger was evaluated to determine the pod loss (kg/ha), pod and fodder yields (kg/ha). This was done in accordance with the Indian Standards Test Codes for groundnut harvester, Animal drawn (IS: 11235 – 1985). The following formulas were used in the computations of the performance indicators.

$$\% Exposed\ Pod\ loss = \frac{G}{A} x\ 100 \qquad 3$$

$$\% Un - dug Pod\ loss = \frac{K}{A} x\ 100 \ldots$$

2

$$\% Un - Exposed\ Pod\ loss = \frac{H}{A} x\ 100 \qquad 3$$

$$A = B + C \qquad 4$$

Check equation 3 again. Equation 1 and 3 have same numerator.

Where;

A = Total quantity of pods collected from the plant in the sampled area.

B = Quantity of clean pods collected from the plant dug in the sampled area, exposed pods lying on the surface and the buried pods.

C = Quantity of damaged pods collected from the plants in the sampled area.

G = Quantity of detached pods lying exposed on the surface.

H = Quantity of detached pods remained inside the soil in the sampled area.

K= Quantity of pods remaining undetached from the undug plants in the sampled area.

Total percentage of pod loss = % of exposed pods loss + % of unexposed pod loss + % of undug pod loss.

Performance Evaluation of the Groundnut Digger

Field evaluation and performance analysis of the groundnut digger was carried out to assess the effect on groundnut varieties, soil moisture contents and soil cutting depths of the digger. The result of the response effect of performance variable of pod yield and fodder yields (kg/ha) and pod loss (kg/ha) are presented. In addition, the data obtained were subjected to statistical test using analysis of variance (ANOVA) and mean separation was done using Fisher unprotected tool.

Results and Discussion

Effect of groundnut variety, soil moisture content and cutting depth on pod and fodder yields and pod loss of animal drawn digger in Sudan Savanna zone of Nigeria

Table 1 shows the effect of groundnut variety, soil moisture content and cutting depth on pod and fodder yields and pod loss of animal drawn groundnut digger in Sudan Savanna zone of Nigeria. Groundnut variety had no significant effect on pod loss of the groundnut digger. However Samnut 26 produced higher pod (1138 kg/ha) and fodder yields (2682 kg/ha) than Samnut 23 (1055.67 and 1882 kg/ha pod and fodder, respectively). Significant differences were observed between the two soil moisture content for pod loss. pod loss of 112.28 (kg/ha) was recorded at 12.4% soil moisture content, while 172.68 kg/ha pod loss was obtained from moisture content of 5.9 or 9.5%?. The increase in pod loss was attributed to the hardness and cracking of the soil, which makes it more difficult for the digger to penetrate and for the pods to get easily loose from the soil resulting in some of the groundnut pods getting hooked within the soil. This result implies that the soil moisture content has influence on the pod loss of the implement. This result is in agreement with the findings by Attanda and Adinoyi (2016) which stated that soil moisture content is a major factor influencing the percentage pod loss of groundnut crop when harvested mechanically.

Furthermore, significant differences ($P \leq 0.01$) were observed between the cutting depths on pod yield (kg/ha) and pod loss (kg/ha) (Table 1). At cutting depth of 15cm, pod yield of 1211.63 kg/ha was measured while pod yield of 968.83 kg/ha was recorded when the digger was set at cutting depth of 10 cm. This result may be attributed to the effect of the digger cutting depth of 10 cm thereby unable to dig out the pods completely from the soil. Singh and Oswalt (1995) have earlier recommended cutting depth of up to 12 – 15 cm for efficient groundnut digging and reduced pod loss. However, pod loss of 78.13 kg/ha was obtained digging at a depth of 15cm and 146.56 kg/ha at a depth of 10cm but a significantly higher pod loss mean of 202.75 kg/ha was recorded with manual harvesting using hoe. In this study, the three cutting depths evaluated 10 cm, 15 cm and manual harvesting indicate that digging at a depth of 15 cm gave better result compared to

digging at 10 cm (considered to be the pod zone) and manual digging The lower pod loss recorded from 15 cm cutting depth may not be unconnected to the fact that the digger dug 5 cm below the groundnut pod zone thereby eliminating pod losses incurred due to mechanical damage during harvesting. These result is in line with findings of Andrew *et al.*(2015) The volumetric moisture content of the soil profile within 10 cm, generally representing the maximum depth to which peanuts pods grow and are dug.

Table 1: Effect of groundnut variety, soil moisture content and cutting depth on pod and fodder yields and pod loss in the use of animal drawn digger in Sudan Savanna zone of Nigeria

Treatments	Pod Yield (kg/ha)	Fodder Yield (kg/ha)	Pod Loss (kg/ha)
Variety (V)			
Samnut 23	1055.67	1881.5	147.19
Samnut 26	1137.81	2681.5	137.77
P of F	0.0090	<.0001	0.5867
SED	28.7	160.5	17.1
LSD	59.5	332.9	35.4
Moisture (M)			
5.9 or 9.5 %	1083.30	2192.6	172.68
12.4 %	1110.18	2370.4	112.28
P of F	0.3592	0.2800	0.0018
SED	28.7	160.5	17.1
LSD	59.5	332.9	35.4
Cutting depth (C)			
10 cm	968.83	2355.6	146.56
15 cm	1211.63	2377.8	78.13
Control	1109.76	2111.1	202.75
P of F	<.0001	0.3401	<.0001
SED	35.1	196.6	20.9
LSD	72.9	407.7	43.3
Mean	1096.740	2281.5	142.48
CV	7.8	21.1	35.9
Interaction			
V x M	**	NS	*
V x C	NS	*	NS
M x C	NS	NS	NS
V x M x C	**	NS	NS

NS = Not significant, *= Significant at 5% probability level, **= Significant at 1% probability level

Effect of Interactions between Variety and Moisture Content on Pod Yield (kg/ha) and Pod Loss (kg/ha) of the Groundnut Digger in Sudan Savanna zone of Nigeria

The combined interaction effect of variety and moisture content on pod yield and pod loss (Table 2) indicates a significant pod yield and pod loss of (1199.70 kg/ha and 124.87 kg/ha, respectively) obtained from SAMNUT 26 variety at a moisture content of 12.4% while SAMNUT 23 recorded a pod yield and pod loss of 1020.65 kg/ha and 99.69 kg/ha respectively. Similarly, at moisture content of 5.9%, both groundnut varieties pod yield and pod loss are statistically at par with SAMNUT 23 recording pod yield and pod loss of 1090.68kg/ha and 194.69 kg/ha, respectively. Also, SAMNUT 26 had a pod yield and pod loss of 1075.93 kg/ha and 150.68 kg/ha, respectively. These results can be attributed to the fact that groundnut harvesting becomes more tedious due to weakening of the pegs and soil compaction as moisture reduces towards the end of the season. This result further revealed that harvesting at the appropriate soil moisture content will ensure reduced pod loss. However, in locations such as Kano, where rainfall ceases mostly before groundnut maturity, it becomes imperative to allow the crop attain maturity before harvesting. The soil moisture at that time may be sufficient for the crop up to maturity, but the soil moisture keeps reducing making harvesting difficult and percentage pod loss gets higher. According to Jordan *et al.* (2013), heavy digging loss is unavoidable when the pegs are weakened due to over maturity or when the soil is very dry and hard.

Table 2: Effect of Interactions between Variety and Moisture Content on Pod Yield (kg/ha) and Pod Loss (kg/ha) of the Groundnut Diggerin Sudan Savanna zone of Nigeria

Variety	Moisture content	Mean Pod Yield (kg/ha)	Mean Pod Loss (kg/ha)
SAMNUT 23	12.4 %	1020.65[a]	99.69[a]
SAMNUT 23	5.9 or 9.5 %	1090.68[a]	194.69[b]
SAMNUT 26	12.4 %	1199.70[b]	124.87[ab]
SAMNUT 26	5.9 or 9.5 %	1075.92[a]	150.68[ab]

Note: Means with the same letter are not significantly different

Effect of Interactions between Variety and Cutting Depth on Fodder Yield (kg/ha) in Performance Evaluation of the Groundnut Digger in Sudan Savanna zone of Nigeria

Results presented in Table 3 showed the combined interaction of groundnut variety and cutting depth and their LSD ranking. The results showed that SAMNUT 23 and 15cm cutting depth accounted for the least fodder yield (1667 kg/ha) while the remaining interactions are statistically at par having significantly higher mean of fodder yield.

Table 3: Effect of Interactions between Variety and Cutting Depth on Fodder Yield (kg/ha) in

Performance Evaluation of the Groundnut Digger in Sudan Savanna zone of Nigeria

Variety	Cutting depth	Mean
SAMNUT 23	15 cm	1667[b]
SAMNUT 23	10 cm	2111[a]
SAMNUT 23	Manual harvesting	1867[a]
SAMNUT 26	15 cm	3089[a]
SAMNUT 26	10 cm	2600[a]
SAMNUT 26	Manual harvesting	2356[a]

Note: Means with the same letter are not significantly different

Table 4: Effect of Variety, Moisture Content and Cutting Depth on Pod Yield (kg/ha) in Sudan Savanna zone of Nigeria

Variety	Moisture	Cutting depth	Pod Yield (Kg/ha)
Samnut 23	12.4 %	15 cm	1144.0[def]
Samnut 23	12.4 %	10 cm	1036.7[bcd]
Samnut 23	12.4 %	Manual harvesting	881.2[ab]
Samnut 23	5.9 or 9.5 %	15 cm	1190.3[efg]
Samnut 23	5.9 or 9.5 %	10 cm	739.2[a]
Samnut 23	5.9 or 9.5 %	Manual harvesting	1342.6[g]
Samnut 26	12.4 %	15 cm	1284.5[fg]
Samnut 26	12.4 %	10 cm	1023.6[cd]
Samnut 26	12.4 %	Manual harvesting	1290.9[g]
Samnut 26	5.9 or 9.5 %	15 cm	1227.7[efg]
Samnut 26	5.9 or 9.5 %	10 cm	1075.9[cde]
Samnut 26	5.9 or 9.5 %	Manual harvesting	924.2[bc]

Note: Means with the same letter are not significantly different
Confirm whether the moisture content is 5.9 or 9.5%?

Effect of Groundnut Variety, Soil Moisture Content and Cutting Depth on Groundnut Pod Loss of Animal Drawn Groundnut Digger

The results presented in Table 4 show the combined interaction of varieties, soil moisture content and cutting depths on groundnut pod yield (kg/ha). Result of the mean ranking revealed significantly higher pod yield of 1342.62 kg/ha recorded in the combined interaction of SAMNUT 23, soil moisture content of 5.9% and manual harvesting using hoe and pod yield of 1290.93 kg/ha obtained in the combined interaction of SAMNUT 26, soil moisture content of 12.4% and manual harvesting using hoe which are statistically at par with the combined interaction of SAMNUT 23, soil moisture content of 5.9% and 15 cm cutting depth, SAMNUT 26, soil moisture content of 12.4% and 15 cm cutting depth with SAMNUT 26, at soil moisture content of 5.9% and 15 cm cutting depth having mean pod yield of 1190.27 kg/ha, 1284.53 kg/ha and 1227.69 kg/ha, respectively Too long and windy sentence. . Also, the combined interactions of SAMNUT 23, soil moisture content of 12.4% and manual harvesting with hoe and the interaction of SAMNUT 23, 5.9% soil moisture content and 10 cm cutting depth accounted for the a least pod yield of 881.24 kg/ha and 739.16 kg/ha, respectively and are statistically at par.

Conclusion

It was concluded that the digger had better performance and lesser pod loss compared to manual digging of groundnut using hoe. Attanda and Adinoyi (2016) reported that deeper cutting depths increased digging efficiency of the groundnut digger and reduced pod loss (kg/ha), while low soil moisture contents reduces digging efficiency of the groundnut digger and increase pod loss (kg/ha).As found from this study, groundnut digger shows no significant effect on groundnut fodder yield compared to harvesting manually using hoe. In a bid to addressing the challenges of drudgery, pod losses and the high cost of harvesting faced by groundnut farmers in Semi-Arid WCA, animal drawn groundnut digger could be recommended. It therefore recommended that appropriate effort should also be made in developing a tractors-drawn groundnut digger from locally available materials and technology. While the animal-drawn digger is suitable for small and medium scale farmers, the tractor-drawn will be suitable for large scale groundnut farmers in the region.

Acknowledgement

The authors are grateful to ICRISAT and the CG CRP Dryland system for financial support of the evaluation of the groundnut digger. We also wish to acknowledge the support of the Head of Department, lecturers and Staff of Department of Agricultural and Environmental Engineering, Bayero University (BUK), Kano, Nigeria for their support.

References

Ademiluyi,Y.S., Oyelade, O.A., James, D. and Ozumba, I.C. (2011). Performance Evaluation of a Tractor Drawn Groundnut Digger/Shaker

for Agricultural Productivity."*Tillage for Agriculture Productivity and Environmental Sustainability" Conference.* February 21-23. Ilorin, Nigeria.

Andrew, C.W., Kendall, R.K., James, S.T., J.W.W., Joel, S.P., Hunter F.M. and Benjamin, F. (2015). Peanut Digging Losses Across Soil Moisture Contents. *2015 ASABE Annual International Meeting Paper. An ASABE Meeting Presentation Paper Number: 152190009, pp. 1 – 7.*

Attanda M. L and Adinoyi A (2016). Effect of Variety, Soil Moisture Content and Cutting Depth on Performance of a Single Row Animal Drawn Groundnut Digger *International Journal of Engineering Trends and Technology (IJETT) – Volume 32 Number 6.* ISSN: 2231-5381 http://www.ijettjournal.org Page 281 – 287.

Dahab, M.H. and Hamad, S.F. (2003). Comparative of Weeding by Animal-Drawn Cultivator and Manual Hoe in En-Nohoud Area. Western Sudan. *Agricultural Mechanization in Asia, Africa, and Latin America (AMA).* 34(3): 27-30.

Dorner, J. W. (2008). Relationship between Kernel Moisture Content and Water Activity in Different Maturity Stages of Peanut.*Peanut Science*, Volume 35. Pg. 77-80.

Food and Agricultural Organization (F.A.O. 1994). Testing and Evaluation of Agricultural Machinery and Equipment: Principles and Practices. *FAO Agricultural services Bulletin.* 110, Rome.

Indian Standard Test Code for Groundnut Digger Animal Drawn IS: 11235. - 1985

Jordan D. L, Brandenburg R. L, Blake Brown A, Gary Bullen S, Roberson G. T, Shew B (2013). 2013 peanut information. North Carolina Cooperative Extension Service, College of Agriculture & Life Sciences, North Carolina State University. Availablefrom:http://www.peanuts.ncsuedu/PDFFiles/005279/2013_Peanut_Information_(NC).

Milles D.W. (1982). Appropriate Technology for Rural Development. *The ITDG experience, Paris-France. Pp.* 5-12.

Nautiyal, P.C. (2002). Post-Harvest Compendium, Food and Agricultural Organization.FAO Groundnut Post-harvest Operations. *A Report of National Research Centre for Groundnut* (ICAR) pg. 2-22

Oyelade, O.A., Ademiluyi, Y.S., James, D. and Ozumba, I.C. (2011). Performance Evaluation of a Modified Tractor Drawn Groundnut Digger/Shaker for Agricultural Productivity. *"tillage for Agriculture Productivity and Environmental Sustainability" Conference.* February 21-23. Ilorin, Nigeria. Pg. 191.

Singh, F. and Oswalt, D.L. (1995). Groundnut Production Practices Skill Development Series no. 3 *Revised,Training and Fellowships Program,* International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India.