# Effect of Variety, Soil Moisture Content and Cutting Depth on Performance of a Single Row Animal Drawn Groundnut Digger

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**Abstract**

*The challenge of providing a more efficient and cost-effective ways of harvesting groundnut amongst the small holder farmers is imperative in northern Nigeria as a result of intensity of labor requirement in the task. It is reported that up to 40 % of the total labor required to grow groundnut is expanded on harvesting operation and at peak harvest periods, labor shortages often occur leading to higher costs of production and subsequent years of reduction in yield due to soil nutrient loss owing to the uprooting method of manure harvesting. In order to assuage some of these challenges, a field test was conducted to evaluate operation performance of a single row animal drawn groundnut harvester developed in the department of Agricultural engineering Bayero University Kano. The effects of the control parameters of; variety of the groundnut seed planted, soil moisture content and cutting depth of the digger were studied on the performance parameters of the harvester as; digging efficiency, percentages of exposed pods loss, unexposed pods loss, undug pods loss and total of pods loss. The results obtained revealed a highly significant difference among the varieties with respect to un-exposed pod loss (%), while moisture content was found to significantly affect exposed pods loss (%), total pos loss and digging efficiency. Varying the cutting depth significantly affected exposed pods (%), un-exposed pods (%), total pod loss and digging efficiency. Interaction between SAMNUT 23, moisture content of 12.4%db and cutting depth of 15 cm had digging efficiency of 97.22%, while the interactions between SAMNUT 26, moisture content of 12.4%db and cutting depth of 15 cm had digging efficiency of 95.14%. The study revealed that higher digging efficiency is obtainable with higher soil moisture content and cutting depth, irrespective of the variety under cultivation, while correlation analysis revealed that digging efficiency and total percentage of pod loss are inversely related, signifying that at lower digging efficiency there would be higher pod loss and vice versa.*

**Keywords:** *Efficiency, moisture content, cutting depth.*

## Introduction

Groundnut (*Arachis hypogaea L.*) is one of the world's most popular crops cultivated throughout the tropical and subtropical area where annual precipitation is within the range of 1000-1200mm for optimum growth of crop. The crop is grown in nearly 100 countries and the most leading producers of groundnut are China, India, Nigeria, U.S.A, Senegal, Indonesia and Sudan (Garba *et al,* 2002). The total world output of the crop in 2012 was 40.1 million metric tonnes out of which Nigeria accounted for 3.1 million metric tons (USDA, 2012). Groundnut has high economic and nutritional potentials and is an important cash crop for peasant farmers in poor tropical countries including Nigeria, China, India, and Myanmar who are the major groundnut growing countries (Garba *et al,* 2002).

Groundnut production in Africa has been estimated at about 4.6 million tonnes with Senegal, Nigeria, Zaire and Sudan being the largest producer in Africa and an annual estimation placed Nigerian production of unshelled nut at about 2.6 million metric tons from a land area of approximately 2.5million hectares. Beside, providing food for man and livestock, groundnut can be an important source of much of the needed foreign exchange for the country (Ashley, 1993). In Nigeria, groundnut is produced in almost all the northern states. The leading producing states include Niger, Kano, Sokoto, Kastina, Kaduna, Adamawa, Yobe, Plateau, Borno, Taraba, Gombe and Nassarawa. According to Aliyu (2016), the following groundnut varieties are released and commonly grown across Northern Nigeria; SAMNUT 10, SAMNUT 11, SAMNUT 21, SAMNUT 22, SAMNUT 23 SAMNUT 24, SAMNUT 25 and SAMNUT 26. The crop is one of the important staple foods in Nigeria and consumed by almost all cultures, despite the difference in food synthesis preparation.

Groundnut harvesting operation is crucial to ensure maximum productivity because even when the harvest occurs at the maturity optimal point, plants contain pods beneath the soil surface and indeterminate growth at different stages of maturation, which may influence the loss in the mechanical digging (Dorner, 2008).Harvesting bottlenecks in the less-developed regions are

commonly caused by the drudgery of lifting plants from the ground. This task is the most mechanized operation in developed countries and replaces the hard manual labor of digging (Nautiyal, 2002).

It takes from 120 – 150 man-hr to harvest a hectare of groundnut, the manual harvesting can cause depletion of soil fertility due to removal of the complete root system along with nitrogenous nodules, however, this can be eliminated using mechanical harvester (Ademiluyi *et al.* 2011).The mechanical harvesting of groundnut has advantage of reducing the cost and labour requirement 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 itself. The search for more efficient, cost-effective ways of harvesting groundnut is significant because of the extreme labor intensity of this task. Nautiyal, (2002) reported that up to 40 percent of the total labor required to grow groundnut is expanded on harvesting operation and that at peak harvest periods, labor shortages often occur leading to higher costs of production or reduction in yields.

**Materials and Methods**

Performance evaluation was conducted for a designed and constructed animal drawn groundnut digger in 2015. The digger has 0.25 ha/hr effective field capacity and pulled by two work bulls evaluated in a sandy loamy soil of the Research and Teaching Farm of the Faculty of Agriculture, Bayero University Kano ($11^0$ 973″ N, $8^0$ 415″ E and 444m above sea level). The treatments were randomly assigned in 2 x 2 x 3 factorial experiment arranged in a randomized complete block design (RCBD) with three replications. The treatments used were: two different soil cutting depths (10cm and 15cm) with a control (Digging manually using hoe); two groundnut varieties (SAMNUT 23 and SAMNUT 26) and 2 soil moisture content (12.4% db and 5.9% db).

Soil moisture content was taken in order to assess 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 design 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. This parameter is the vertical distance between the soil surface and depth of cut as the blade cuts through the ridge. A meter rule was used to determine this value. The averages were recorded as the depth of operation.

The machine was evaluated to determine the percentages of damaged pods, exposed pods loss, unexposed pods loss, undug pods loss, total pods loss and digging efficiency. This was done in accordance with the Indian Standards Test Codes for groundnut harvester, Animal drawn (IS: 11235 – 1985).  In which the effective field capacity of the digger was found to be 0.25ha/hr. The following formulas were used in the computations of the performance indicators.

$$\% \, Exposed \, Pod \, loss = \frac{G}{A} \, x \, 100 \dots\dots\dots\dots\dots\dots\,(1)$$

$$\% \, Un-dug \, Pod \, loss = \frac{K}{A} \, x \, 100 \dots\dots\dots\dots\dots\dots\,(2)$$

$$\% \, Un-Exposed \, Pod \, loss = \frac{G}{A} \, x \, 100 \dots\dots\dots\dots.\,(3)$$

$$A = B + C \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.\dots\dots\,(4)$$

$$Digging \, Efficiency(\%) = 100 - Total \, pod \, loss..\,(5)$$

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.

The data obtained were subjected to statistical test using analysis of variance (ANOVA). Statistical software (GenStat 17 Edition) was used for the analysis while mean separation was done using Fisher unprotected tool.

**Results and Discussion**

**Effect of Variety, Moisture Content and Cutting Depth on Exposed pod loss (%)**

The result from analysis of variance for effect of variety, moisture content and cutting depth on

exposed pod losses is presented in Table 1. The result revealed no significant difference between the two groundnut varieties (SAMNUT 23 and 26). However, highly significant differences (P≤0.01) were observed for soil moisture contents and also the cutting depths.

The means of treatments are presented in Table 2. The lowest percentage of exposed pods loss of 4.20% was recorded at soil moisture content of 12.4%, while at 5.9% soil moisture content, the percentage exposed pods loss was 7.16%. For cutting depth, the lowest percentage exposed pods losses (2.70%) was recorded when the groundnut digger was set at a cutting depth of 15 cm, while at 10 cm cutting depth and manual harvesting using hoe had exposed pod loss of 7.18% and 7.17% respectively. From the results obtained, it is clear that delay in harvesting after physiological maturity can result in many pods left in the soil due to weakening of pegs and when the blade cut deeper into the soil, the pods are exposed and the weakened pegs easily drop their pods on the surface of the soil. This agrees with the findings of Singh and Oswalt (1995) that delay in harvesting after physiological maturity can result in pod losses due to weakening of pegs. It is therefore possible to reduce this loss through harvesting at appropriate soil moisture content and cutting the soil bellow the pod zone of 7 – 12cm as reported by Ademiluyi*et al* (2004).

**Effect of Variety, Moisture Content and Cutting Depth on Percentage Un-Exposed pod loss of Groundnut**

Highly significant (P≤0.01) pod losses were recorded among the groundnut varieties, with pod loss due to different cutting depths varying significantly. However, no significant difference in pod loss was observed on the moisture contents of the soil (Table 1). The mean effects of variety and cutting depth on percentage un-exposed pod loss revealed that SAMNUT 23 variety had the highest percentage un-exposed pod loss of 6.87%, while SAMNUT 26 had 4.54% (Table 2). For cutting depths, harvesting with the groundnut digger at depth of 15cm had percentage Un-exposed pod loss of 3.19%, followed by cutting depth of 10cm (5.57%), while the manual digging had percentage un-exposed pod loss of 8.36%. This shows that increase in the depth of cut, results in to decrease in the number of pods left in the soil. This agrees with Ademiluyi *et al* (2011) that cutting depth has an effect on pod exposure.

**Effect of Variety, Soil Moisture Content and Cutting Depth on Percentage Un-dug pod loss**

The result for mean effect of variety, soil moisture content and cutting depth on percentage un-dug pod loss is presented in Table 2. There was no significant difference observed among the treatments. No significant interaction was also observed between the treatments. This result may be attributed to the fact that the digger was designed to dig one row at a pass, and the width of the cutting edge of the machine is wide enough to cut the ridge from one end to the other thereby leaving no plant un-dug during operation.

**Effect of Variety, Soil Moisture Content and Cutting Depth on Total pod loss of Groundnut**

The results revealed no significant difference between the two varieties (SAMNUT 23 and 26). However, highly significant differences (P ≤0.01) were observed among the soil moisture contents and also the cutting depths (Table 1). The total pod loss of 9.27% was obtained when harvested at soil moisture content of 12.4%. Harvesting at moisture content of 5.9% had the highest total pod loss of 13.87%. At a cutting depth of 15 cm, lower total pod loss of 5.89% was obtained, compared to manual harvesting from which total pod loss of 15.52% was recorded (Table 2). Significant interaction (P≤0.05) was also observed between the groundnut varieties used, moisture content and cutting depth on pod loss of groundnut (Table 3). Significant interaction with the lowest total pod loss was observed between SAMNUT 23 x moisture content of 12.4% x cutting depth of 15 cm with a value of 2.78%. A substantial percentage total pod loss of 20.97% was recorded when SAMNUT 23 was harvested at soil moisture content of 5.9% and cutting depth of 10 cm.

**Effect of Variety, Soil Moisture Content and Cutting Depth on Digging efficiency of Groundnut**

The results revealed no significant difference between the varieties. However, highly significant differences (P≤0.01) were obtained for soil moisture contents and cutting depths. The mean effects of soil moisture content and cutting depth are presented in Table 2. The highest digging efficiency of 90.73% was recorded with soil moisture content of 12.4%, while the lowest digging efficiency of 86.14% was obtained from digging at soil moisture content of 5.9%. This decrease in digging efficiency was mainly due 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 (most of the groundnut pods get hooked within the soil). This implies that the soil moisture content has direct influence on the digging efficiency of the implement. This agrees with the findings by Ademiluyi *et al.* (2011) on performance evaluation of a tractor drawn groundnut digger, that soil moisture content is a major factor influencing the digging efficiency of the implement. The cutting depth of 15 cm was found to have the highest digging efficiency of 94.10%, while manual

digging (control) had an efficiency of 84.48%. Singh and Oswalt (1995) had earlier recommended a cutting depth of 12 – 15 cm below the soil surface for blade harrow.

The interaction effects of variety, soil moisture content and cutting depth on digging efficiency are presented in Table 3. The result revealed significant interaction (P≤0.05) between variety, moisture content and cutting depth on digging efficiency. The interaction between SAMNUT 23 x moisture content of 12.4% x cutting depth of 15 cm had digging efficiency of 97.22%. Also, the interactions between SAMNUT 26 x moisture content of 12.4% x cutting depth of 15 cm had digging efficiency of 95.14%. Lower digging efficiencies were recorded from interactions between SAMNUT 23 x soil moisture content of 5.9% x cutting depth of 10cm and SAMNUT 26 x soil moisture content of 5.9% x control with digging efficiencies of 79.03% and 83.04% respectively. From these results, it is clear that higher digging efficiency is obtainable with higher soil moisture content and cutting depth, irrespective of the variety under cultivation.

Correlation analysis (Figure 1) revealed that digging efficiency and total percentage of pod loss are inversely related to one another signifying that at lower digging efficiency there would be high percentage of total pod loss and vice versa. This result is in line with the findings of Oyelade *et al* (2011) on the performance evaluation of a modified tractor drawn groundnut digger/shaker for agricultural productivity which state that digging efficiency and total percentage of pod loss are inversely related to one another.

**Conclusions**

On the bases of significant results obtained from the field experiments, the following conclusions can be drawn;

  i.  Field test results revealed that soil moisture content and cutting depth plays a vital role in the digging efficiency of the groundnut digger.

 ii.  The highest digging efficiency of 97.22% was recorded using the developed digger to dig SAMNUT 23 at a moisture content of 12.4% and 15cm soil cutting depth.

iii.  Digging efficiency and total percentage of pod loss are inversely related to one another signifying that at lower digging efficiency there would be high percentage of total pod loss and vice versa.

 iv.  From the results, it is clear that higher digging efficiency is obtainable at higher soil moisture content and cutting depth, irrespective of the variety under cultivation.

Table 1.Analysis of variance for different pod looses and digging efficiency of groundnut digger

| Source of variation | Degree of freedom. | Exposed pod (%) | Un-Exposed pod loss (%) | Un-dug pod loss (%) | Total pod loss (%) | Digging efficiency (%) |
|---|---|---|---|---|---|---|
| Rep | 2 | 39.831 | 6.899 | 1.187 | 48.99 | 48.99 |
| Variety (V) | 1 | $12.865^{ns}$ | $49.218^{**}$ | $1.187^{ns}$ | $20.41^{ns}$ | $20.41^{ns}$ |
| Moisture content (M) | 1 | $78.882^{**}$ | $14.488^{ns}$ | $1.187^{ns}$ | $189.81^{**}$ | $189.81^{**}$ |
| Cutting depth (C) | 2 | $79.914^{**}$ | $80.291^{**}$ | $1.187^{ns}$ | $305.21^{**}$ | $305.21^{**}$ |
| V x M | 1 | $16.237^{ns}$ | $0.093^{ns}$ | $1.187^{ns}$ | $29.41^{ns}$ | $29.41^{ns}$ |
| V x C | 2 | $19.176^{ns}$ | $26.225^{*}$ | $1.187^{ns}$ | $0.71^{ns}$ | $0.71^{ns}$ |
| M x C | 2 | $1.401^{ns}$ | $32.297^{**}$ | $1.187^{ns}$ | $50.4^{*}$ | $50.4^{*}$ |
| V x M x C | 2 | $22.618^{*}$ | $12.936^{ns}$ | $1.187^{ns}$ | $76.48^{*}$ | $76.48^{*}$ |
| Residual | 22 | 6.539 | 4.767 | 1.187 | 14.74 | 14.74 |
| Total | 35 | | | | | |

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

**Table 2 Mean for performance evaluation of developed animal drawn groundnut digger**

| Treatments | Exposed pods loss (%) | Un-exposed pod loss (%) | Un-dug plant loss (%) | Total pod loss (%) | Digging Efficiency (%) |
|---|---|---|---|---|---|
| Variety (V) | | | | | |
| Samnut 23 | 5.08 | 6.87 | 0.36 | 12.32 | 87.68 |
| Samnut 26 | 6.28 | 4.54 | 0 | 10.82 | 89.18 |
| **P of F** | **0.175** | **0.004** | **0.328** | **0.252** | **0.252** |
| SED | 0.852 | 0.728 | 0.363 | 1.280 | 1.280 |
| LSD | 1.768 | 1.509 | 0.753 | 4.597 | 2.654 |
| Moisture (M) | | | | | |
| $M_1$ () | 4.20 | 5.07 | 0 | 9.27 | 90.73 |
| $M_2$ () | 7.16 | 6.34 | 0.36 | 13.87 | 86.13 |
| **P of F** | **0.002** | **0.095** | **0.328** | **0.002** | **0.002** |
| SED | 0.852 | 0.728 | 0.363 | 1.280 | 1.280 |
| LSD | 1.768 | 1.509 | 0.753 | 4.597 | 2.654 |
| Cutting depth (C) | | | | | |
| $C_1$ (15 cm) | 2.70 | 3.19 | 0 | 5.89 | 94.11 |
| $C_2$ (10 cm) | 7.18 | 5.57 | 0.54 | 13.29 | 86.71 |
| Control | 7.17 | 8.36 | 0 | 15.52 | 84.48 |
| **P of F** | **<.001** | **<.001** | **0.328** | **<.001** | **<.001** |
| SED | 1.044 | 0.891 | 0.445 | 1.567 | 1.567 |
| LSD | 2.165 | 1.848 | 0.922 | 6.501 | 3.250 |
| **Mean** | **5.68** | **5.70** | **0.18** | **11.57** | **88.4** |
| CV | 45.0 | 38.3 | 600 | 33.2 | 4.3 |
| Interaction | | | | | |
| V x M | NS | NS | NS | NS | NS |
| V x C | NS | * | NS | NS | NS |
| M x C | NS | ** | NS | * | * |
| V x M x C | * | NS | NS | * | * |

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

**Table 3: Effect of Variety, Moisture Content and Cutting Depth on Total Pod Loss and Digging efficiency (%) in Performance Evaluation of the Developed Single Row Animal Drawn Groundnut digger**

| Groundnut Variety | Soil moisture content (%) | Cutting depth (cm) | Total pod loss (%) | Digging efficiency (%) |
|---|---|---|---|---|
| SAMNUT 23 | 12.4 | 15 | 2.7846[a] | 97.2153[f] |
| SAMNUT 23 | 12.4 | 10 | 6.5555[abc] | 93.4444[def] |
| SAMNUT 23 | 12.4 | Control | 18.0257[ef] | 81.9742[ab] |
| SAMNUT 23 | 5.9 | 15 | 10.7667[bcd] | 89.2332[cde] |
| SAMNUT 23 | 5.9 | 10 | 20.9749[f] | 79.0250[a] |
| SAMNUT 23 | 5.9 | Control | 14.8249[def] | 85.1750[abc] |
| SAMNUT 26 | 12.4 | 15 | 4.8597[ab] | 95.1402[ef] |
| SAMNUT 26 | 12.4 | 10 | 11.1309[abd] | 88.8690[cde] |
| SAMNUT 26 | 12.4 | Control | 12.2805[cde] | 87.7194[bcd] |
| SAMNUT 26 | 5.9 | 15 | 5.1478[ab] | 94.8521[ef] |
| SAMNUT 26 | 5.9 | 10 | 14.5133[def] | 85.4866[abc] |
| SAMNUT 26 | 5.9 | Control | 16.9638[def] | 83.0361[abc] |
| Grand mean | | | 11.5690 | 88.4324 |
| Error | | | 2.4215 | 2.4215 |
| CV | | | 36.2541 | 4.7429 |

Note: Means with the same letter are not significantly different
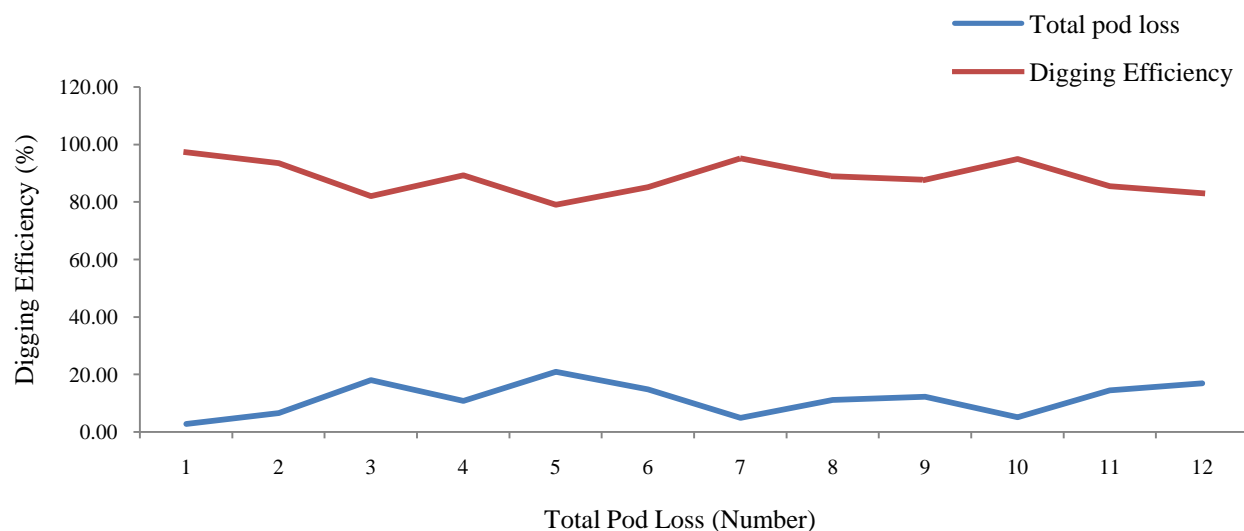


**Figure 1: Correlation Between Total Pod Loss and Digging Efficiency**

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