



# Effects of Groundnut Shell Incorporation Rates on the Growth and Yield of Maize (*Zea mays* L.) in Mubi, Adamawa State, Nigeria

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## Authors' contributions

This work was carried out in collaboration among all authors. Author IRD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors IJT and ATG managed the analyses of the study. Authors IRD and ATG managed the literature searches. All authors read and approved the final manuscript.

## Article Information

DOI: 10.9734/BJI/2021/v25i330141

### Editor(s):

(1) Prof. Antar El-Banna, Kafrelsheikh University, Egypt.

### Reviewers:

(1) R. Sridevi, Vellore Institute of Technology, India.

(2) Balwinder Kumar, Guru Angad Dev Veterinary and Animal Sciences University, India.

(3) Vinicius Politi Duarte, Federal University of Lavras, Brazil.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/60829>

Original Research Article

Received 05 July 2020  
Accepted 10 September 2020  
Published 29 June 2021

## ABSTRACT

**Purpose:** The aim of the study was to assess the effects of groundnut shell incorporation rates on the growth and yield of maize.

**Research methods:** The study was carried out at the students' demonstration farm of the Federal Polytechnic, Mubi, Adamawa State, in 2018. Seeds were sown on a prepared land treated with four (4) doses of groundnut shells (0, 25, 50 and 75 tons/ha) arranged in a randomized complete block design (RCBD), replicated 4 times. Each plot was marked out at 2.0 m length × 2.0 m width with 0.5 m gap between the replicated plots and blocks. Maize growth parameters were determined at 2, 4, 6 and 8 weeks after sowing and maize yield parameters were determined at 10 and 12 weeks after sowing (WAS).

**Findings:** The groundnut shell application rates increased maize growth parameters such as, plant height, number of leaves per plant, leaf area index, and stem girth, number of cobs per plant and

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cobs weight. The results revealed that plant height, number of leaves, leaf area index and stem girth were significantly ( $P \leq 0.05$ ) influenced by the treatments, except for the control treatment at 2- WAS. The higher application rates (50 and 75 t/ha) of groundnut shell significantly ( $P \leq 0.05$ ) influenced the plant growth components better than the 25 and 0 t/ha treatment rates.

**Research limitations:** There were no limitations to report.

**Originality/Value:** The results suggests that groundnut shell incorporation rate at 50 t/ha could be recommended as the most appropriate and profitable for high performance of maize plants in Mubi. The results generally suggest that maize plants may tolerate even higher rates of groundnut shell incorporation beyond the rates used in the study.

*Keywords: Groundnut shell; soil; fertilizer; yield; incorporation-rate.*

## 1. INTRODUCTION

Maize (*Zea mays* L.) is one of the major important cereal crops that is cultivated year round and provides staple food to the rapidly growing human population in the world, especially, sub-Saharan Africa. The crop is high yielding and rich in nutrition, with diversified uses [1]. Maize is a heavy feeder and mines essential nutrients from soils in large amounts. However, low soil fertility has been identified as a major factor reducing maize yields in Nigeria. Low farm inputs is one of the factors responsible for the cause of low and declining state of crop yields in many countries of the Sub-Saharan Africa [2]. The problem of low soil fertility amidst scarcity of mineral fertilizers around Mubi area have triggered attempts to use organic fertilizer sources to replenish soil nutrients at low cost. Besides, the high cost of inorganic fertilizers and its frequent adulteration, makes the product to have adverse effects on soils, water and plants. There exists the need to find other fertilizer sources for maintaining soil fertility to enhance optimum maize yields. Lucas [3] reported that sometimes, the application of organic manure might be more important than the addition of chemical fertilizers to some crops. Consequently, maize yields very well in a continuously cropped field, but declines with time, even with the application of certain mineral fertilizers. The decline in soil productivity due to continuous cultivation in Nigeria has been acknowledged as one of the main causes of food insecurity and poverty. To achieve food adequacy, there is the pressing need to manage the soil infertility problem, improving crop productivity in these soils is essential for socio-economic reasons. Application of inorganic fertilizers provides an alternative to overcome soil infertility. But the solitary application of inorganic fertilizers caused degradation of soil health and decreased its productive capacity. The shells are the dry pericarp of the mature pods contains moisture

content, crude fibre, lipids, crude protein, carbohydrate, oxalate, phytate, cyanogenic glycosides and trypsin inhibitors of 8.0%, 2.50%, 59%, 0.50%, 4.43%, 25.57%, 220 mg/100 mg, 362.1 mg/100 kg, 1.60 mg/100 g and 25 TUI/mg, respectively [4]. Groundnut shell contains calcium, phosphorus, potassium, magnesium, zinc and more than 10 kinds of other trace elements, small amount of fat and protein [2].

Groundnut shell fertilizer has dual effects; firstly, by providing required nutrients to growing plants, and secondly, by feeding soil organisms. A balanced blend of groundnut shell fertilizer provides food sources for important micro-organisms, which in turn help plants ability to uptake more nutrients from the soil. The use of groundnut waste in agriculture can reduce the need for chemical fertilizers and it restores organic carbon deficiency in soils [5]. As chemical fertilizers are causing ecological damage, an alternative method is required to replace the use of chemical fertilizers for the growth of maize plants. Groundnut shell produced during processing is used as a natural fertilizer for cultivation. According to Pietraszko and De-Clereq [6], application of groundnut shell fertilizer has less effect on invertebrate animals in the soil. At present, there is no scientific data on the effects of groundnut shell fertilizer materials on maize production in the study area, thereby making its incorporation rates to be without precision. Thus, there is lack of information on recommendable groundnut shell incorporation rates for maize production around Mubi and environs. This study therefore aims to provide scientific data on the subject towards providing suitable information on maize production practices among farmers in Mubi environs.

The aim of the research work was to assess the effect of groundnut shell on growth and yield of maize.

## 2. MATERIALS AND METHODS

### 2.1 Description of the Study Area

The study was carried out in Mubi North Local Government Area (LGA) of Adamawa State, Nigeria. It has a land area of 506.4 km<sup>2</sup> with an approximate population size of 759.45 people at a density of 160.5 persons per square kilometer [7]. Its eastern boundary belts the Nigeria Cameroon border by the Mandara mountain ranges. Mubi also borders Michika and Hong LGAs to the Northern and Southern parts, respectively. The town is located in the sub-sudan vegetation belt falling within latitude 10° 27" N and longitude 13° 28" E. It stands at an altitude of 600 meters above sea level at the foot of the Mandara Mountains that separate Nigeria from the Cameroon. The climate of the area is characterized by alternating dry and wet seasons. The rain starts from April to October with a mean annual rainfall ranging from 700 mm to 1,262 mm as documented by Adamawa Agricultural Development Programme (AADP), Mubi weather station (2017). The vegetation is of typical Sudan Savanna type, which connotes grassland interposed by shrubs and few trees, mostly *Acacia*, *Eucalyptus* and locus bean trees among others [8,9]. According to Hiol et al. [10], the dominant physical features in the area are the Mandara Mountain which runs along the Cameroon-Nigeria border with a height of about 1200-1500 m above sea level. The soil type is clayey sand mixed with gravels predominately found on a gentle to steep slopes and dissected land surfaces. Tekwa et al. [9] reported that land use types are mainly arable farming and livestock production threatened by soil erosion at varying levels of devastation by sheet, rill and gully erosion known for colossal loss of soil nutrients. Even though, structural degradation occurs combined with increasing impermeability of the soils, the area is still noted for considerable production of variety of crops including maize, cotton, vegetables, sorghum, millet, cowpea, garden egg and groundnuts under strategized management [10].

### 2.2 Preparation of Groundnut Shells

The groundnut shells were obtained from a groundnut shelling machine in Mubi. The groundnut shells were grounded into small sized particles for easy incorporation.

### 2.3 Experimental Design and Treatments

The experiment consists of 4 levels of groundnut shell incorporation rates at 0, 25, 50 and 75

tons/ha dry matter basis. The experiment was laid out in a randomized complete block design (RCBD) with 4 replications. There were 4 plots per block each measuring 2 m × 2 m making a total plot size of 8 m<sup>2</sup> and 16 plots in total. A 0.5 m alley was left between plots within a replication and between replications.

### 2.4 Land Preparation and Experimentation

The experimental field was demarcated prior to experimental setup and was cleared using a cutlass and a hoe while ploughing was done using a tractor. The total land area was 9.5 m × 9.5 m making a total size of 90.25 m<sup>2</sup>. After laying-out, the crushed groundnut materials were then applied to the plots at 4 levels (0, 10, 20, 30 kg) equivalent to 0, 25, 50 and 75 tons/ha by soil incorporated methods. The soil incorporation of organic materials and levelling were done manually using a hoe. The seeds were planted at a spacing of 80 cm between rows and 50 cm within rows. Two seeds were planted per hill. The hybrid has a maturity period of 90-95 days (3 months).

### 2.5 Weed Management

Prior to planting, glyphosate (non-selective) herbicide was applied to kill all weeds to avoid early competition. The first hand weeding was done 18 days after sowing (DAS) and the second hand weeding was done 40 DAS. Third hand weeding was done after 75 DAS.

### 2.6 Harvesting

After crop maturity in the field, harvesting of 40 cobs per plot was done harvested maize was dried, bagged and labelled according to treatments, replications and plot numbers.

### 2.7 Determination of Maize Plant Growth Parameters

#### 2.7.1 Plant height

Plant height was measured using a meter tape at 2, 4, 6 and 8 weeks after sowing (WAS). The measurement was taken from the plant base to the tip of the shoot and then recorded

#### 2.7.2 Number of leaves per plant

The number of maize leaves was physically counted and respectively recorded at 2, 4, 6 and 8-WAS.

### 2.7.3 Leaf Area Index (LAI)

Leaf area index was measured using a ruler at 2, 4, 6, and 8-WAS. The leaf width and length were first measured and the leaf area was computed from the results and then recorded.

### 2.7.4 Stem girth

Data on stem diameter of representative maize seedlings (stand) on each plot was measured using a Vernier caliper at 2, 4, 6 and 8-WAS.

## 2.8 Determination of Maize Yield Components

### 2.8.1 Number of cob per plant

The number of cobs was physically counted and recorded at 8, 10 and 12-WAS.

### 2.8.2 Cob weight

The maize cob was harvested when matured and weighed using a weighing balance. Cob weight per maize plant per plot was then recorded for further analysis.

## 2.9 Data Analysis

The data collected was subjected to a generalized linear model of Statistix 9.1 (2012) for the analysis of variance (ANOVA). Plot means were compared using the least significant difference (LSD) and were separated using standard error (SE) at 0.05 level of significance.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of Groundnut Shell Incorporation Rates on Maize Plant Heights

Table 1 presents the results of the effect of groundnut shell incorporation rates on maize plant heights in Mubi. The results showed that

the treatment effects was not significantly ( $p \leq 0.05$ ) different at 2-WAS. The plants treated with 25, 50, and 75 t/ha of groundnut shell had similar heights at both 4 and 6-WAS, but were however, significantly ( $p \leq 0.05$ ) different from those on the control plots with shorter plant heights. At 8-WAS, the maize plant heights became relatively uniform with no significant ( $p \leq 0.05$ ) differences among the treatment effects. This outcome was perhaps due to attainments in the heights of the maize plants at their advanced growth stage. It was also observed that additional application of the fertilizer material increased the maize plant heights proportionally, though insignificantly. The relatively comparable treatment effects of the fertilizer material on the plant heights at 2-WAS could have been due to insufficient decomposition. Conversely, the observed similarities among 25, 50 and 75 t/ha application rates was perhaps due to uniform release of stocked plant nutrients in the fertilizer material, regardless of the study intervals. This claim also agrees with the assertion of Olatunji et al. [11], who reported that maize grown with groundnut shell performed better than with other manure types.

### 3.2 Effects of Groundnut Shell Incorporation Rates on Number of Leaves on Maize Plants

Table 2 presents the results of the effects of groundnut shell incorporation rates on the number of leaves of maize plants in Mubi. The results showed that the treatment effects were not significantly ( $p \leq 0.05$ ) different at 2, 4 and 8-WAS, respectively. The plants treated with 25, 50 and 75 t/ha of groundnut shell had similar number of leaves at 6-WAS, which were however, significantly ( $p \leq 0.05$ ) different from those on the control plots with fewer number of leaves. It was also observed that

**Table 1. Effect of groundnut shell incorporation rates on maize plant heights at 2, 4, 6 and 8-WAS**

Treatment (t/ha)	Plant heights (cm)			
	2-WAS	4-WAS	6-WAS	8-WAS
0	13.80	14.29 <sup>b</sup>	33.50 <sup>b</sup>	86.76
25	16.98	20.22 <sup>a</sup>	38.17 <sup>ab</sup>	87.90
50	18.56	19.58 <sup>a</sup>	38.99 <sup>ab</sup>	97.09
75	19.49	22.22 <sup>a</sup>	44.43 <sup>a</sup>	105.81
SE± (0.05)	NS	1.9136	3.7015	NS

Key: Means in a column with the same notations are not significantly ( $P \leq 0.05$ ) different at 0.05 level of significance

**Table 2. Effects of groundnut shell incorporation rates on the number of leaves on maize plants at 2, 4, 6 and 8-WAS**

Treatment (t/ha)	Number of leaves			
	2-WAS	4-WAS	6-WAS	8-WAS
0	4.45	5.25	8.85 <sup>b</sup>	9.91
25	4.30	5.60	9.55 <sup>ab</sup>	10.38
50	4.55	5.65	9.80 <sup>ab</sup>	10.16
75	4.80	5.68	11.05 <sup>a</sup>	11.16
SE± (0.05)	NS	NS	0.6701	NS

Key: Means in a column with the same notations are not significantly ( $P \leq 0.05$ ) different at 0.05 level of significance

**Table 3. Effects of groundnut shell incorporation rates on maize plant leaf area index at 2, 4, 6 and 8-WAS**

Treatment (t/ha)	Leaf area index (mm)			
	2-WAS	4-WAS	6-WAS	8-WAS
0	1.67 <sup>b</sup>	2.09 <sup>b</sup>	4.17 <sup>b</sup>	11.19
25	1.97 <sup>b</sup>	2.11 <sup>b</sup>	4.71 <sup>b</sup>	13.98
50	2.02 <sup>b</sup>	2.24 <sup>ab</sup>	4.73 <sup>b</sup>	10.04
75	2.52 <sup>a</sup>	2.69 <sup>a</sup>	8.38 <sup>a</sup>	12.18
SE± (0.05)	0.1927	0.2506	1.5079	NS

Key: Means in a column with the same notations are not significantly ( $P \leq 0.05$ ) different at 0.05 level of significance

**Table 4. Effects of groundnut shell incorporation rates on the maize plants stem girth at 2, 4, 6 and 8-WAS**

Treatment (t/ha)	Stem girth (mm)			
	2-WAS	4-WAS	6-WAS	8-WAS
0	3.00 <sup>b</sup>	7.35 <sup>b</sup>	16.02	17.20
25	4.32 <sup>b</sup>	8.65 <sup>ab</sup>	17.30	19.14
50	4.74 <sup>a</sup>	9.47 <sup>a</sup>	18.95	21.53
75	4.93 <sup>a</sup>	9.40 <sup>a</sup>	19.72	22.25
SE± (0.05)	0.5452	0.9026	NS	NS

Key: Means in a column with the same notations are not significantly ( $P \leq 0.05$ ) different at 0.05 level of significance

**Table 5. Effects of groundnut shell incorporation rates on the maize cob weights and number of cobs at 10 and 12-WAS**

Treatment (t/ha)	Number of cobs		Cob Weight (kg)
	10-WAS	12-WAS	12-WAS
0	0.95	1.00	333.08 <sup>ab</sup>
25	1.00	1.05	392.70 <sup>ab</sup>
50	1.05	1.18	325.97 <sup>a</sup>
75	1.18	1.20	462.67 <sup>a</sup>
SE± (0.05)	NS	NS	60.39

Key: Means in a column with the same notations are not significantly ( $P \leq 0.05$ ) different at 0.05 level of significance

additional application of the fertilizer material increased the number of leaves of the maize plants fair proportionally. The relatively comparable treatment effect of the fertilizer materials on the number of leaves at both 2 and 4-WAS could have been due to insufficient

decomposition. Conversely, the observed similarities among 25, 50 and 75 t/ha application rates was perhaps due to uniform release of inherent plant nutrients in the groundnut shells, regardless of the study intervals.

### 3.3 Effects of Groundnut Shell Incorporation Rates on Leaf Area Index of Maize Plants

Table 3 presents the results of the effects of groundnut shell incorporation rates on leaf area index of maize plants in Mubi. The results show that the treatment effects were significantly ( $p \leq 0.05$ ) different in this study. The plants treated with 0, 25, and 50 t/ha of groundnut shell had similar leaf area index at 2, 4 and 6-WAS, but were significantly ( $p \leq 0.05$ ) different from those on the control plots with lower leaf area index. At 8-WAS, the maize plants leaf area index showed no significant ( $p \leq 0.05$ ) differences among the treatments. The relatively comparable treatment effects of the groundnut shells on the leaf area index at 2, 4 and 6-WAS perhaps due to sufficient decomposition of soil organic matters.

### 3.4 Effects of Groundnut Shell Incorporation Rates on Stem Girth of Maize Plants

Table 4 presents the results of the effects of groundnut shell incorporation rates on maize plant stem girths in the study area. The treatment with 0 t/ha of ground nut shells gave the lowest mean stem girth of maize in this study, while 75 t/ha gave the highest mean stem girth. The results further reveals that there was significant ( $p \leq 0.05$ ) differences among the treatments on the maize stem girths at 2 and 4-WAS. Unlike at 8-WAS, there was no significant ( $p \leq 0.05$ ) difference among the treatments effects on the maize stem girths. This agrees with the findings of Anon [12], who reported that groundnut shell is an excellent fertilizer material because of its high nitrogen, phosphorus and potassium content and it is readily available than the mineral fertilizer. In addition, its effect on the soil is stable and with slow nutrition to maize plants.

### 3.5 Effects of Groundnut Shell Incorporation Rate on the Maize Cob Weights and Number of Cob

Table 5 presents the results of groundnut shell incorporation rates on maize number of cobs at 10 and 12-WAS. The results showed that there was no significant ( $P \leq 0.05$ ) differences among the treatment effects on the maize cobs at 10 and 12-WAS. However, the treatment effects were proportional to the treatment rates. The results also show that there was a significant ( $P \leq 0.05$ ) differences among the treatment effects on the maize cob weights in this study. The 75

tons/ha treatment rate produced the heaviest maize cob weights (462.67 kg), followed by the 50 tons/ha treatment, which produced 325.97 kg of maize cobs. The 0 tons/ha and 25 tons/ha application rates did not differ in their effects on the maize cobs in this study. Anon [12], similarly found that higher application rates of groundnut shell produced heavier maize cob weights, than with lower application rates. This further underscores the assertion about maize as one of the heavy feeders of soil nutrients. Hence, its yielding ability is often proportional to fertilizer application rates [11,5,1].

## 4. CONCLUSION AND RECOMMENDATIONS

The field experiment was conducted during the 2018 raining season to investigate the effects of groundnut shell incorporation rates (0, 25, 50 and 75 t/ha) on the growth and yield of maize (*Zea mays*) on plots marked out on a 2.0 m x 2.0 m at an alley of 0.5 m covering 9.5 m x 9.5 m experimental area laid in RCB design. The results revealed that plant height, number of leaves, leaf area index and stem girth were significantly ( $p \leq 0.05$ ) influenced by the treatments, except for the control treatment at 2-WAS. The higher application rates (50 and 75 t/ha) of groundnut shell significantly ( $p \leq 0.05$ ) influenced the plant growth components better than the 25 and 0 t/ha treatment rates. The results generally suggested that maize plants may tolerate even higher rates of groundnut shell incorporation beyond the rates used in this study. From the results, it could be concluded that higher rates (50 and 75 t/ha) of groundnut shell increased both growth and yield components of maize plants in the study area. However, the 25 t/ha rate trialed well than the untreated control (0 t/ha) which could not significantly improve maize performance in this study.

From the results,, it is recommended that future trials should involve higher rates of groundnut shell manure sources, other than the amounts used for the purpose of this study. Therefore, farmers are recommended to use the 75 t/ha of groundnut shell manure in order to achieve better performance of maize plants around Mubi and environs.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

The peer review history for this paper can be accessed here:

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