Effects of Tillage Types on Soil Chemical Properties, Growth and Yield of Groundnut (*Arachis hypogaea* L)

[1] Emmanuel C. P., [2]Alama I. S., [(*)] [3] Okon U., [4] Uwabor S. C, [5] Onwudiwe N., [6] Offeoritse F. O., [7] Otite O. F., [8] Eni E. [9] Okonjo E.

[1, 3] Department of Soil Science, Faculty of Agriculture, Akwa-Ibom State University, Oruk Anam, Akwa-Ibom State, Nigeria

[2,4,6,7,8] Department of Soil and Land Resource Management, Faculty of Agriculture, Dennis Osadebay University, Asaba, Delta State, Nigeria

[5,9] Department of Crop Science and Management, Faculty of Agriculture, Dennis Osadebay University, Asaba, Delta State, Nigeria

Corresponding Author: ask.ifeakachukwu@gmail.co; alama.sunday@dou.edu.ng

ABSTRACT

Tillage plays a significant role in crop production, the study purpose was to determine the effect of tillage types: Flat till (FT), Mound till (MT) and Ridge till (RT) on the chemical properties, growth and yield of groundnut**.** The experiment was carried out in a randomized complete block design (RCBD) to ascertain the effect of tillage types on soil chemical properties. Plant height, leaf area, weight (Fresh/Dry) and number of leaves were measured and subjected to ANOVA and treatment means were compared using FLSD (Fisher's Least Significant Difference). The results revealed that the different tillage types significantly improved soil pH {5.03 (FT)}, organic matter {3.25% (MT)}, available phosphorus {23.73mg/kg (FT)} and base saturation {77.79% (RT)}, cation exchange capacity {7.31cmol/kg (RT)}, and Nitrogen {0.22 **(**MT)}. The study established that leaf area {12.25 (MT)}, number of branches {16.83 (RT)} and plant height with value 52.92 (RT) compared to FT and MT. The highest yield observed was 0.28kg plant^{-1} (flat till), compared to 0.27kg plant^{-1} (ridge till), and 0.20kg plant^{-1} (MT) with a significant difference between tillage types ($P<0.05$). This study showed that flat tillage significantly improved the growth and yield of groundnut, and also enhanced chemical properties except for nitrogen.

Keywords: Tillage, growth, yield, groundnut, chemical properties

INTRODUCTION

Groundnut is an energy-rich crop and needs a sufficient amount of nutrients and moisture to meet its requirements for growth, development and high yields. Sustainable groundnut production is ascribed to adopting nutrient management techniques (Kumar and Salakinkop, (2017). Tillage, therefore, contributes to sustainability in weed management (Obiazi *et al.,* 2024), erosion control, evaporation reduction, seedbed preparation, and improved water infiltration. The advantages add up to root development, growth and higher crop yields (Bhatt, 2019; de Sousa, and Grichar, 2024). Draycott (2006) and Blunk *et al.,* (2021) in their study on tillage practices revealed that direct sowing may result in lower crop yield than conventional tillage. The tillage effect on yield output is enhanced by creating the appropriate seed conditions for plant emergence, development, and unhindered root expansion, thus, crops planted using different tillage methods have different or fluctuating characteristics (Al-Kaisi and Yin, 2005).

Tillage enhances root vertical and horizontal proliferation, increases root volume, and removes impedance that could otherwise prevent root proliferation (Lio, 2006; Azam 2024). Tillage has a significant effect due to microbial activity that influences soil aeration, moisture, temperature, bulk density, penetration, resistance, water intake, and water extraction by plant roots (Tripathi *et al.,* 2007). The conventional and conservational tillage systems have been prompted by the hunt for good tillage systems (Kay and Vanden Byaart, 2002). In contrast, conventional tillage exposes soil to factors that could increase nutrient mineralization and content of organic matter which improves the porosity and water-holding capacity of the soil (Khan *et al.,* 2001; Alama *et al.,* 2024), compared to a conservational tillage approach. Conventional tillage increases copper, manganese, and iron levels in arable soil (Kraska *et al.,* 2014). According to Jabro *et al.,* (2009), it is important to adopt a tillage pattern that best preserves the soil's physical qualities required for the sustainability of crop production. Despite the role of tillage in crop production most farmers globally lack knowledge and information on the utilization of tillage. Hence, the study's objective was to ascertain how types of tillage affects groundnut growth, yield, and the chemical characteristics of soil.

MATERIALS AND METHOD

The Study Area

The investigation took place within AkwaIbom State University, Research Farm, Obio Akpa Campus, Oruk Anam Local Government Area, AkwaIbom State, Nigeria from March 31, 2019, to August 30, 2020. The area is situated between latitude latitude $4^0 50^1$ and 4^0 57^1N and longitude 7^0 45^1 and 7^0 55^1E. (Udo *et al.,* 2021) and it is located within the Humid Tropical Rain Forest, characterized by two seasons; rainy (March – October) and dry (November – early March) seasons with a short dry period in August otherwise called August break. This region receives high rainfall of between 2000–2500 mm (Ekwere, and Efretuei, 2021). The temperature of 23.27°C and the relative humidity ranges from 75%-79%; the soils were acidic and the vegetation is mostly secondary forest (Alama *et al.,* 2021; Udofia and Udoh, 2021).

Soil Sampling and Analysis

Composite samples (soil) were delineated at depths 0 to 30cm at the commencement of the experiment and was taking to the laboratory for analysis of the physicochemical properties after completion of the first and the second cropping cycle. Soil pH was measured in a 1:2:5 soil water suspension (Nel *et al.,* 2022). Particle size distribution was established by the Bouyoucos hydrometer method after dispensing the soil sample with sodium hexametaphosphate (calgon) solution (Okalebo, *et al., 2002*). Bulk density (Bd) was ascertained by the core sampler method (Grossman, and Reinsch, 2002), Determination of SOC by Walkley and Black method (Ramamoorthi and Meena, 2018) while Kjeldahl method was used for the determination of nitrogen (Bremner, 1965), P by Bray and Kurtz No. 1 method (Bender and Wood, 2000), K by ammonium acetate method (Knudsen *et al.,* 1982), cation exchange capacity (CEC) was ascertained by summing up total exchangeable bases (TEB) (Uzoho and Irokwe, 2020). Base saturation was ascertained using TEB and ECEC.

Experimental Designs and Treatment Application

The research was carried out using three tillage types (Zero till, Mound till and Ridge till) in a randomized complete block design. Each replication was 12 plots, each plot measured 2 by 4m. The distance between blocks was 1m, while that of plots within a replicate was 1m. The plot was cleared, mapped, and planted at the various tillage types as required by the experiment.

Agronomic Practices

The groundnut was sown immediately after the first rain which was on the 31st of March 2020. Seeds were treated with an insecticide (Emamectin benzoate) to prevent insects and fungal attacks (Dodiya *et al.,* 2024). Three seeds were planted at a depth 3-5cm per stand at a spacing of 0.4m by 1m and plant population was 108 plants. A blanket application of poultry manure and potassium was done a week before and two weeks after crop emergence and weed was kept free and controlled manually.

Collection of Data on Growth and Yield

Data collected was within four mid rows of groundnut stands, agronomic variables measured were height, and leaf area index which was assessed by measuring the length and maximum breath of randomly chosen functional leaves and multiplied with a factor of 0.75 (Kiniry *et al.,* 2005). The data was taken at two weekly intervals, threshing (%) 100 seed weight, pod and seed yields ($6ha^{-1}$) were taken at crop harvest.

Data Analysis:

The data collected was analyzed using SAS (2012) for variance analysis at 5% probability level while Fisher's Least Significant Difference (FLSD) was used to compare the significant treatment means.

RESULTS AND DISCUSSION

Initial Soil Test Result (Chemical Properties) Before Planting:

The initial soil test result before treatment application indicates that the textural classes of soils are mostly loamy sand with sand at 85.00%, silt at 5.00%, and 10.0% clay respectively (Hazelton and Murphy 2007). The soil properties adversely affected crop growth because of low water and nutrient holding capacity. The pH was very strongly acidic (4.68), and was ascribed to leaching and high amounts of rainfall leading to less of microbial activities and potency of certain toxic chemicals.

The organic matter (3.72%) contents were low, this values are less than 10% given by Afu *et al.,* (2019) as ideal for healthy soils essential for improved crop production. The nitrogen value was 0.81% (high) which was above the initial limit of 0.15%. The high level of nitrogen supports plants' rapid growth and encourages the development of healthy foliage, fruiting and crop yield (Lalmuanpuii *et al*., 2025; Sharma *et al.,* 2025). Exchangeable calcium was 13.16cmol/kg which was reported high above the critical value of <20cmol/kg (Chude *et al.,* 2011). Exchangeable magnesium content was 5.39cmol/kg, this value was higher than the critical value of 0.05cmol/kg needed in soil (Ubi *et al.,* 2013). The exchangeable sodium value was 0.53cmol/kg compared to the critical value of 0.1cmol/kg needed in soil. Exchangeable K was very high (1.71cmol/kg) and the value was higher compared to the critical level of 0.20cmol/kg as reported by Chude *et al.,* (2011). This level of K may lead to a reduction in magnesium and calcium uptake by plants.

Available phosphorous value was 17.67mg/kg compared to the critical value of 0.05mg/kg the phosphorus level suggests moderate range, but its implication on groundnut production depends on several factors such as adequate root development, improved nodulation, pod formation and yield (Bekele et al., 2023; Asante et al., 2020). Effective cation exchangeable capacity ECEC was 25.47cmol/kg which was above the critical value of 20cmol/kg regarded to be suitable for crop production (Chude *et al.,* 2011). The base saturation (BS) value was 81.63% which is an indication that a significant portion of the soil's cation exchange capacity (CEC) is occupied by essential base cations like calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), and sodium (Na^{+}). This has several implications for groundnut production such as favourable soil pH, improved nutrient availability and potential need for potassium management (Ma *et al*., 2024).

Table 1: Results of chemical properties before treatment application at (0.15cm) depth.

Soil properties	Values
pH (H20) 1:2.5	4.68
EC (ds/m)	0.016
Organic matter (%)	3.72
Total nitrogen (%)	0.81
Available phosphorus (mg/kg)	17.67
Exchangeable bases	Values
Ca (Cmol/kg)	13.16
Mg (Cmol/kg)	5.39
Na (Cmol/kg)	0.53
K (Cmol/kg)	1.71
Exchangeable acidity (Cmol/kg)	4.68
ECEC (Cmol/kg)	25.47
Base saturation	81.63
Particle size distribution	Values
Sand (%)	85.00
Silt (%)	5.00
Clay (%)	10.00
Textural class	Loamy sand

Table 2: Cultural practices followed in groundnut production

Cultural practices	Groundnut
Variety	SAMNUT-16 (M554.76)
Spacing	0.4m by 1m
Date of planting	31st of March 2020
Planting Season	2019/2020
Planting depth	3-7cm
Water management	rain-fed
Insect and diseases management	No pests or diseases found
Weed control	hand weeding
Maturity	4 months
Harvesting	August 2019/2020

Main Effect of Tillage Types on Soil Chemical Properties.

Soil pH

Tillage types had a significant effect on pH ($P<0.05$). Flat tillage had a mean pH value of 5.03 (highest), ridge plots had 4.58 and mound plots had the lowest pH value of 4.15. The values obtained in mound plots could be ascribed to the rate of microbial events and OM decomposition to enhance soil pH. The practices lead to a decrease in pH. Hence, MOP changed pH from very strongly acidic to moderately acidic soil as reported by Karki *et al.,* (2021). This agreed with the result obtained by Ahmed *et al.,* (2024) who observed no tillage could affect soil pH. This difference could be attributed to environmental factors and differences in crop and soil characteristics.

Organic matter (OM)

Different tillage types improved OM. The highest OM content was obtained in mound tillage at 3.25%, followed closely by flat tillage at 3.24% while ridge tillage was 3.06%. This significant increase in soil OM confirms that OM breakdown is aided by tillage practices through aeration and microbial activity, and could also be associated with structural development and stability of soils (Alama *et al.,* 2023). Adekiya *et al.,* (2011) observed a similar trend in their study on soil properties concerning tillage effects, this suggests a moderate level of organic material, which can have several implications for soil health and productivity relating to improves nutrient availability by acting as a reservoir for essential elements like nitrogen, phosphorus, and potassium.

Total nitrogen (TN)

Tillage types had no significant effect on TN; the nitrogen decrease could be ascribed to the uptake of nitrogen by the plant even though groundnut fixes nitrogen, and the uptake exceeds the residual soil nitrogen. This result agreed with Tekulu, *et al.,* (2020) who attributed the low total N content after harvesting groundnut to sandy soils with low SOM content and leaching of nitrate below the rooting depth. Adekiya *et al.,* (2011) observed a trend of soil OM showing potential OM decomposition and total nitrogen release. Nitrogen is a crucial nutrient for groundnut (peanut) production, as it supports plant growth, pod development, and overall yield. A nitrogen level of 0.22 mg/kg in soil is relatively low, which may have several implications such as limited nitrogen fixation – Groundnuts are legumes and can fix atmospheric nitrogen through symbiotic relationships with rhizobia bacteria. However, if soil nitrogen is too low, initial plant growth may be slow before nodulation occurs. Insufficient nitrogen can lead to stunted growth, poor foliage development, and lower pod formation, ultimately reducing yield. This may need supplementation – Farmers may need to apply nitrogen-rich fertilizers or organic amendments (such as compost or manure) to improve soil fertility and enhance groundnut productivity (Bationo *et al.,* 2011; Noor *et al.,* 3024)

Available phosphorous (AvP)

Tillage types significantly improved phosphorous. Flat tillage available phosphorous value were 23.73mg/kg, followed by mound tillage at 17.63mg/kg while ridge tillage had the least mean available P 14.13mg/kg respectively. This result agreed with Ahmed *et al.* (2020) and Alama (2024) who observed a similar trend of improved phosphorous in tillage practice for spring maize.

Table 3: Main effects of tillage types on soil chemical properties.

Soil pH	Organic matter	Total N (mg/kg)	Av.P (mg/kg)	CEC (cmol/kg)	ECEC (cmol/kg)	BS
5.031^{a}	3.24^{a}	0.08^{a}	23.73^{a}	5.36^{b}	7.613^{b}	67.80^{b}
4.15^{b}	3.25^{a}	0.22^{b}	17.63^{b}	5.23^{b}	7.38^{b}	71.04^{b}
4.58^{a}	3.06^{a}	0.10^{a}	14.13^{b}	7.31^{a}	9.16^{a}	77.79^{a}
1.09	0.25	0.17	9.73	1.34	1.38	6.56

Means that do not share a letter are significantly different CEC= Cation exchange capacity; ECEC= Effective cation exchange capacity.

Effective cation exchange capacity (ECEC)

The effect of tillage types on ECEC after harvest was significant ($p<0.05$), ridge till was 9.16cmol/kg followed by flat tillage (7.613cmol/kg) while mound tillage had the least value. The higher the ECEC the more the negative charge and more cations seen in soil. Vasudevan *et al.,* (2009) had a similar result on tillage effects in soil.

Base saturation (BS)

Tillage types significantly increased base saturation ($p<0.05$). Ridge tillage had a base saturation of 77.79% followed by mound tillage (71.04%) while flat tillage had the least base saturation (67.80%). Thus, a pH and BS positive relationship was reported by caires *et al.,* (2006).

Tillage Types Effect on Growth of Groundnut Plants:

Tillage effect on plant height (cm) after treatment application.

Tillage systems significantly affected groundnut height at different growth stages. Groundnut height varied between 34.75-52.92cm at 6, 8 and 12 weeks after treatment. Ridge tillage recorded the highest mean value of 52.91cm and mound tillage 47.83cm while at 12 weeks respectively the mean value was 47.41cm in flat tillage and there was no significant tillage effect on plant height.

Table 4: Comparison of leaf area, no of branches and plant height (cm) for tillage at 6, 8, 12 weeks after planting (WAP).

Tillage types	Leaf area			No of branches			Plant Height		
	6WAP	8WAP	12WAP	6WAP	8WAP	12WAP	6WAP	8WAP	12WAP
Flat tillage	12.19[a]	10.35[a]	11.60[a]	8.00[a]	10.83[b]	15.08[b]	35.25[a]	40.83[a]	47.42[a]
Ridge tillage	12.19[a]	11.03[a]	12.00[a]	8.25[a]	12.50[ab]	16.83[a]	37.00[a]	44.50[a]	52.92[a]
Mound tillage	12.25[a]	10.03[a]	10.12[a]	7.83[a]	12.33[b]	15.33[b]	34.75[a]	38.38[b]	47.83[a]
LSD (0.05)	2.57	2.13	2.83	1.89	1.77	1.70	6.29	5.95	6.51

Means that do not share a letter are significantly different.

Tillage effect on groundnut number of branches at 6WAP, 8WAP, and 12WAP:

Considering the various tillage types: flat, mound, and ridge tillage types groundnut branches increased significantly at $p<0.05$. Under ridge tillage, groundnut had more branches of 104% (16.83) compared to other types of tillage. Mound tillage was followed by 95.79% (15.33) while flat tillage produced the least number of branches 12 weeks after planting. Tillage had an effect significantly on the number of branches at 12WAP ($p=0.49$) at a 0.05 level of significance.

Tillage effect on leaf area of groundnut:

The tillage methods effect was not significant ($p>0.05$). Leaf area (12.25cm2) at 6WAP obtained in groundnut plants grown on mound tillage was the highest followed by ridge tillage (12.19cm2) while those grown on mound at 8WAP and 12WAP had the least leaf area ($10.12\pm10.03cm^2$). The result shows that tillage types had no substantial effect on groundnut leaf area throughout the growth period. Supplementary application of K promoted growth biomass in various crops (Meena *et al.,* 2015).

Tillage Types Effect on Yield of Groundnut Plants:

Tillage effects on fresh weight of groundnut after harvesting

Fresh weight refers to the weight recorded immediately after the ground plant is harvested. Table 05. sows the fresh weight means of ground plant yield. The table shows that flat till fresh weight (0.28kg) was the highest followed by Ridge till (0.27kg) while mound till gave the least fresh weight (0.20kg) and their mean differences were significant ($P<0.05$). This result agreed with a field trial conducted by Rboh and Ahmed (2010) which showed that tillage types had a substantial effect on the fresh weight of groundnut plants. Tillage practices play a crucial role in determining the fresh weight of groundnut after harvesting by influencing soil structure, moisture retention, and nutrient availability. Research suggests that different tillage methods—such as flat tillage, mound tillage, ridge tillage—affect groundnut growth and yield differently (de Sousa and Grichar 2024; Wasaya *et al.,* 2019).

Table 5: Main effects of tillage `types on the yield of groundnut

Tillage types	Fresh weight(kg)	f groundnut pods	No of seeds per plant	Weight of seeds (kg)
Flat tillage	0.28[a]	69.42[a]	105.25[a]	0.02[a]
Ridge tillage	0.27[a]	77.83[ab]	103.75[ab]	0.02[a]
Mound tillage	0.20[a]	57.33[a]	62.67[b]	0.02[a]
LSD(0.05)	0.11	31.94	48.62	0.00

Means that do not share a letter are significantly different.

Most groundnut pods (77.83) were produced by ridge tillage compared to other tillage techniques while the highest number of seeds (105.25) were produced by flat tillage; the mean differences were statistically significant ($p<0.05$).

Effects of tillage types on the numbers of groundnut pods

Tillage types significantly affected the number of groundnut pods and varied between 57.33 – 69.42; at harvest ridge tillage had more pods (77.83) followed by flat tillage (69.42) and mound tillage (57.33). The mean difference between ridge-till and flat till was significant compared to mound tillage. The result from the experiment agreed with Ogban and Babalola, (2002).

Effects of tillage types on the number of groundnut seeds

The result showed that flat till had the highest number of seeds (105.25 seeds) followed by those planted on the ridge (103.75) while those planted on the mound gave the least number of seeds (62.67 seeds). This result is also in agreement with the field trial conducted by Rboh and Ahmed (2010). The mean differences were significant ($p<0.05$) hence tillage types significantly affected the number of groundnut seeds.

CONCLUSION

The findings of the study showed that soil nutrient elements changes depend heavily upon tillage type and tillage equipment used**.** The tillage types had a significant effect on chemical properties, with the concession of nitrogen, which was ascribed to plant uptake after groundnut harvest, low OM leached below the subsurface horizon. Groundnuts grown on flat tillage seeds had 105.25 followed by those grown on ridge and mound which gave the least seeds number. These results would provide some useful information on the appropriate tillage type for groundnut production

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