EFFECTS OF TILLAGE METHODS AND SOIL DEPTHS ON SOIL CHEMICAL PROPERTIES IN SOUTH EASTERN NIGERIA

Nwachukwu C.P.[1], Orakwe L.C.[2], Nwajinka C.O.[3], Umembamalu C.J.[4], and Anizoba D.C.
[1,2,3,5] Department of Agricultural and Bioresources Engineering, Nnamdi Azikiwe University, Awka
[4]Department of Chemical Engineering, Nnamdi Azikiwe University, Awka
Corresponding Authors email: cp.nwachukwu@unizik.edu.ng
Corresponding Authors Phone number: 08037462819

ABSTRACT

Mechanical movement in agricultural land affects soil properties, thereby leading to poor yield. In this study, selected soil chemical properties were assessed under different tillage methods and soil depths at the experimental farm site of the Department of Agricultural and Bioresources Engineering, Nnamdi Azikiwe University, Awka, Southeastern Nigeria. Three tillage practices were involved in this study; conventional tillage- by properly tilling the soil with plough and harrow, conservative tillage- tilling with one tractor pass, and no tillage- without tilling the soil. The soil chemical properties tested were; pH, soil nitrogen, soil potassium, soil phosphorous, soil electrical conductivity and soil organic carbon content. Soil samples were collected from each of the tillage methods at different soil depths; 0-25cm, 25-50cm 50-75cm and 75-100cm soil depths and tested in the laboratory for these soil chemical properties. The effects of tillage methods and soil depths on soil chemical properties were determined using statistical analysis of variance (ANOVA).From the pH result, a mean pH of 7.02, 6.08 and 6.51 were obtained for conservative tillage, conventional tillage and no tillage respectively, for electrical conductivity, a mean electrical conductivity of 52.1µs/cm, 52.9µs/cm and 54.4µs/cm were obtained for conservative tillage, conventional tillage and no tillage respectively. For soil potassium, means of 7.6ppm, 7.79ppm, and 7.82ppm were obtained for conservative tillage, conventional tillage and no tillage respectively. Result of soil organic carbon gave average of 6.8g/kg, 6.4g/kg and 6.8g/kg for conservative tillage, conventional tillage and no tillage respectively, while for soil nitrogen, mean of 1.5g/kg, 1.25g/kg and 1.67 g/kg were obtained for conservative tillage, conventional tillage and no tillage respectively. Result of soil phosphorous gave averages of 5.46mg/kg, 4.77mg/kg and 4.81mg/kg for conservative tillage, no tillage and conventional tillage respectively. The ANOVA result shows that only soil electrical conductivity and soil nitrogen were significant at $p \leq 0.05$ level.

Keywords: Conventional tillage, conservative tillage, no tillage.

1.0 INTRODUCTION

Extreme climatic factors (temperature, precipitation etc) which at times lead to drought and flooding affect crop yield negatively, apart from the climatic factors, poor soil quality as a result of vehicular movement leads to compaction, compaction leads to depletion of the soil nutrients and this affects crop yield. Compaction also affects the hydraulic conductivity, which is necessary for prediction of water flow and transportation of solute in the soil (Odonez-Morales *et al* 2019).The soil plays a very important role in the agroecosystems, the most important role of the soil are to capture, store and regulate water(kuzucua and Dokmend, 2015).

Conservative and no tillage are used as to improve the conservation of agricultural soils (Fabrizi 2005). Saiful Islam *et al*(2015) conducted an experiment to determine the effects of tillage practices on soil chemical properties, tillage practices showed no significant effect on soil organic matter, while tillage practices nor residue management had any significant effect on soil pH, nitrogen, available phosphorous and potassium. Tillage practices by the use of agricultural machineries affect soil properties in agricultural lands and this affects crop yield. Tillage practices affect soil pH, soil oxidation reduction potential, soil temperature and soil moisture content (Kladivko, 2001). Improper land use, agriculture, pasture and urbanization leads to soil degradation, this declines the soil physical, biological and chemical properties. Improper soil cultivation through improper tillage breaks up soils into finer particles ant this leads to erosion and loss of soil nutrients. On a short term scale, tillage operations mainly affect nutrient dynamics through altering of physical properties of the soil and by incorporating crop residues and mineral or organic fertilizers (Neugschwandtner *et al* 2014).

In Nigeria, due to increasing population and increasing food demand, many farmers pay little or no attention to soil conservation, tillage practices that destroy the soil structure and reduce the soil nutrients are practiced. There is needfor the evaluation of some important soil chemical properties under different tillage methods and soil depths at the experimental farm site of Agricultural and Bioresources Engineering, Nnamdi Azikiwe University, Awka Anambra Southeastern Nigeria.

2.0 MATERIALS AND METHOD

2.1 Study area

Soil samples were collected at the Department of Agricultural and Bioresources Engineering Experimental Site/ Farm Workshop, Nnamdi Azikiwe University, Awka. The site lies between latitudes 6°15’11.8N to 6°15’5.3E and longitudes 7°7’118N to 7°7’183N and altitude of 142m. Dry season temperature ranges from 20°C to 38°C which increases evapotranspiration, while rainy season temperature ranges from 16 to 28°C,with lower evapotranspiration. The soil samples were collected in the dry season of 2017 using auger.

2.2 Soil Sampling

The experimental plot was divided into three subplots, with each subplot representing each of the three tillage methods (conventional tillage, conservative tillage and no tillage). Soil samples were collected from each subplot at different soil depths (0-25cm, 25-50cm, 50-75cm and 75-100cm soil depths) using the soil auger. The collected soil samples were air dried, sieved, labeled and taken to the laboratory for the determination of various soil chemical properties.

2.3 Determination of Soil Chemical Properties

2.3.1 Soil pH

This was determined in the laboratory using Laboratory pH meter Hana model H1991300 (APHA, 1998).

2.3.2 Soil Electronic Conductivity (EC)

Soil electronic conductivity was measured according to APHA 2510 B guidelines Model DDS-307 (APHA, 1998).

2.3.3 Soil Organic Carbon Content (OC)

This is the amount of carbon found in the soil and was based on the Walkely-Black chromic method.

2.3.4 Soil Nitrogen (N)

Nitrogen is one of the elements required for life and it simulates above ground growth, available nitrogen in the soil was be measured in the lab using Kjeldahl method.

2.3.5 Soil phosphorus (P)

Determination of soil available phosphorus was done in the lab using standard method 4500-P B.5 and 4500-PE (ALPHA, 1998).

2.3.6 Soil potassium (K)

Available potassium in the soil was determined using atomic absorption spectrophotometer according to the method of APHA (1995)

2.4 Statistical Analysis

Analysis of variance (ANOVA) was done using the excel solver.

3.0 RESULTS AND DISCUSSION

3.1 Soil pH

From the pH result presented in Fig. 1, pH decreased with increase in soil depth for conservative tillage with values of 7.07, 7.05, 7.01 and 6.98 for, 0-25cm, 25-50cm, 50-75cm and 75-100cm soil depths respectively, the same trend was also observed in no tillage with values of 7.07, 7.05, 7.01 and 6.98 for 0-25cm, 25-50cm, 50-75cm and 75-100cm soil depths respectively. The decrease in pH with increase in soil depth for conservative and no tillage was as a result of minimum disturbance of the soil in the two methods, which did not allow much movement of water down the soil layer. A different trend was observed in conventional tillage pH remained constant with value of 6.79 at 0-25cm, 25-50cm, and 50-75cm soil depths, there was a slight decrease of 6.78 at 75-100cm soil depth. The mean pH was 7.02, 6.787, and 6.51 for conservative tillage, conventional tillage and no tillage respectively, this is in agreement with the observation by Kahlon and Singh, 2014 where conventional tillage and no tillage were applied in a sandy loam soil, the mean highest pH of 7.43 was observed in conventional tillage while a lower mean pH of 7.34 was observed in no tillage. The pH values obtained falls within the acceptable range of ph values optimum for most crops. According to the acceptable pH range for crop growth is 6.5 - 7.8 (Patel and Lakdawala 2014).

Table 1 Effects of Tillage Methods and Soil Depths on Soil pH

Soil Depth (cm)	Soil pH		
	Conservative Tillage	Conventional Tillage	No Tillage
0-25	7.07	6.79	6.99
25-50	7.05	6.79	6.92
50-75	7.01	6.79	6.10
75-100	6.98	6.78	6.03
Mean	7.02	6.79	6.51

Table 2 Analysis of Variance (ANOVA) of the Effect of Tillage Methods on SoilpH

	SS	Df	MS	F	p at 0.05	Fcrit
Between	0.536	2	0.2683	3.0112	0.9	4.2
Within	0.8019	9	0.0891			
Total	1.3385	11				

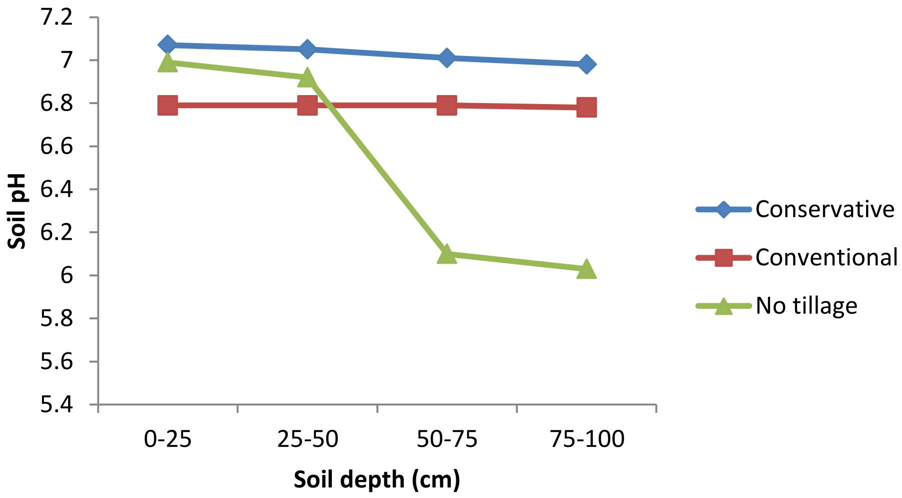

Fig 1: Effect of Soil Depths on Soil pH

3.2 Soil electrical conductivity (EC)

From the result of soil electrical conductivity presented in Fig. 2, increase in soil depth decreased soil electrical conductivity for the three tillage methods. For conventional tillage, electrical conductivity decreased from 53.9µs/cm to 50.6µs/cm, for conservative tillage, it decreased from 54.4µs/cm to 51.9µs/cm, while for no tillage, there was a decrease from 55.6µs/cm to 53.7µs/cm. The decrease in electrical conductivity with increase in depth is as a result of decrease in soil temperature, because soil electrical conductivity increases with increase in temperature (Wei *et al* 2013). A mean average electrical conductivity of 52.1µs/cm, 52.9µs/cm and 54.4µs/cm were obtained for conservative tillage, conventional tillage and no tillage respectively, in contrast, Kahlon and Singh (2014) and Patni *et al* (1998) reported decrease in soil electrical conductivity under no tillage, which might be due to more downward movement of salts along with infiltration into deeper layers. The result of the soil electrical conductivity obtained falls within the normal range of soil electrical conductivity of range of <0.8ds/m or <800µs/cm as recorded by Patel and Lakdawala (2014).

Table 3: Effect of Tillage Methods and Soil Depths on Soil Electrical Conductivity

Soil Depth (cm)	EC(µs/cm)		
	Conservative Tillage	Conventional Tillage	No Tillage
0-25	53.9	54.4	55.6
25-50	52.1	53.5	54.4
50-75	51.8	52.1	54.0
75-100	50.6	51.9	53.7
Mean	52.1	52.9	54.2

Table 4:Analysis of Variance (ANOVA) of the Effect of Tillage Methods on SoilElectrical Conductivity

	SS	Df	MS	F	p at 0.05	Fcrit
Between	11.031	2	5.5159	4.1733	0.05	4.25
Within	11.895	9	1.13217			
Total	1.3385	11				

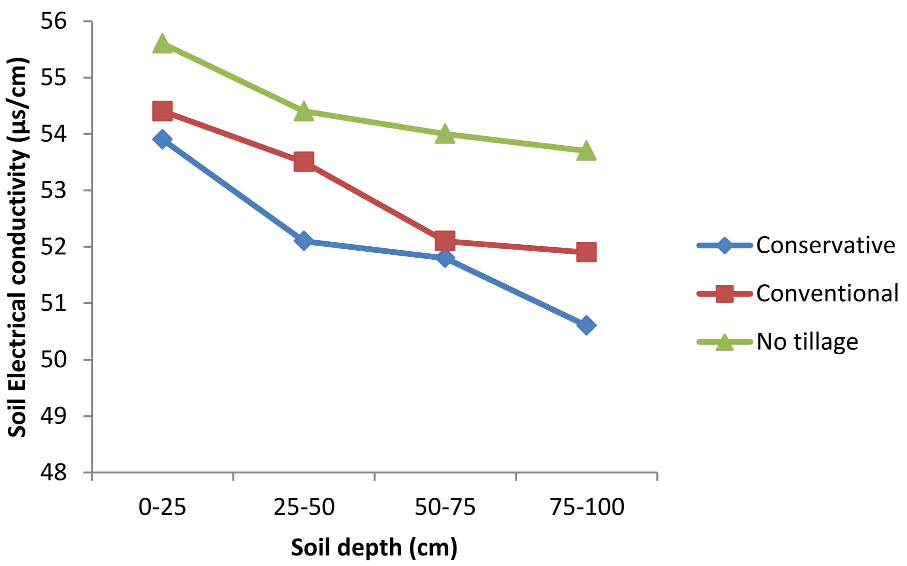

Fig 2: Effects of Soil Depths on Soil Electrical Conductivity

3.3 Soil potassium

From the results presented in Fig 3, increase in soil depth decreased soil potassium for the three tillage methods. The mean soil potassium for the tillage treatments were 7.6ppm, 7.79ppm, and 7.9ppm for conservative tillage, conventional tillage and no tillage respectively. The mean highest tillage was in no tillage, followed by conventional tillage, and the least mean potassium was in conservative tillage. This is in agreement with the findings by Saiful *et al*., (2015) in which the highest mean potassium was in no tillage, followed by conventional tillage. Accumulation of soil potassium occurred in upper part of no tillage with a value of 9.376ppm. the result shows that there was more accumulation of potassium in conventional tillage than conservative tillage.

Table 5: Effect of Tillage Methods and Soil Depths on Soil Potassium

Soil Depth (cm)	Soil Potassium(ppm)		
	Conservative Tillage	Conventional Tillage	No Tillage
0-25	7.975	8.975	9.376
25-50	7.757	8.014	8.209
50-75	7.565	7.576	7.399
75-100	7.105	6.623	6.314
Mean	7.60	7.796	7.824

Table 6: Analysis of Variance (ANOVA) of the Effect of Tillage Methods on Soil Potassium

	SS	Df	MS	F	p at 0.05	Fcrit
Between	0.1193	2	0.0597	0.0684	0.94.2	
Within	8.2906	9	0.9212			
Total	8.4099	11				

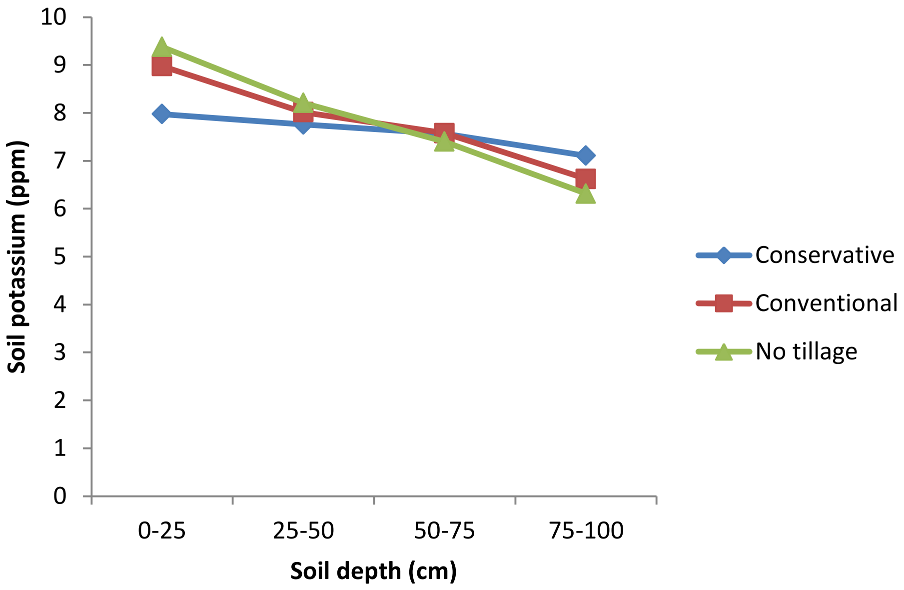

Fig 3: Effects of Soil Depth Soil Potassium

3.4 Soil Organic carbon content (OC)

From the result of soil organic carbon content in Fig 4, soil organic carbon content reduced with increase in soil depth for the three tillage methods with an average soil organic content of 6.8g/kg, 6.4g/kg and 6.9g/kg for conservative tillage, conventional tillage and no tillage respectively. This is in agreement with the report by Kahlon and Singh (2014) who reported the highest average soil organic carbon content in no tillage, with a value of 3.01g/kg and the lowest average soil organic content of 2.58g/kg in conventional tillage, with a value of 2.58g/kg. The highest mean soil organic carbon content is in no tillage because no tillage reduces soil disturbance, improves soil maintenance and benefits soil quality. Zentner *et al*., (2004) reported 14-17% higher soil organic carbon in surface soil under no tillage than conventional tillage practices.

Table 7: Effect of Tillage Methods and Soil Depths on Soil Organic Carbon Content

Soil Depth (cm)	Organic Carbon (g/kg)		
	Conservative Tillage	Conventional Tillage	No Tillage
0-25	9.1	9.3	10.6
25-50	6.4	6.1	6.3
50-75	6.0	5.4	5.5
75-100	5.9	5.0	5.1
Mean	6.8	6.4	6.8

Table 8: Analysis of Variance (ANOVA) of the Effect of Tillage Methods on Soil Organic Carbon Content

	SS	Df	MS	F	p at 0.05	Fcrit
Between	0.455	2	0.2275	0.0545	0.94	4.25
Within	37.5875	9	4.1764			
Total	38.0425	11				

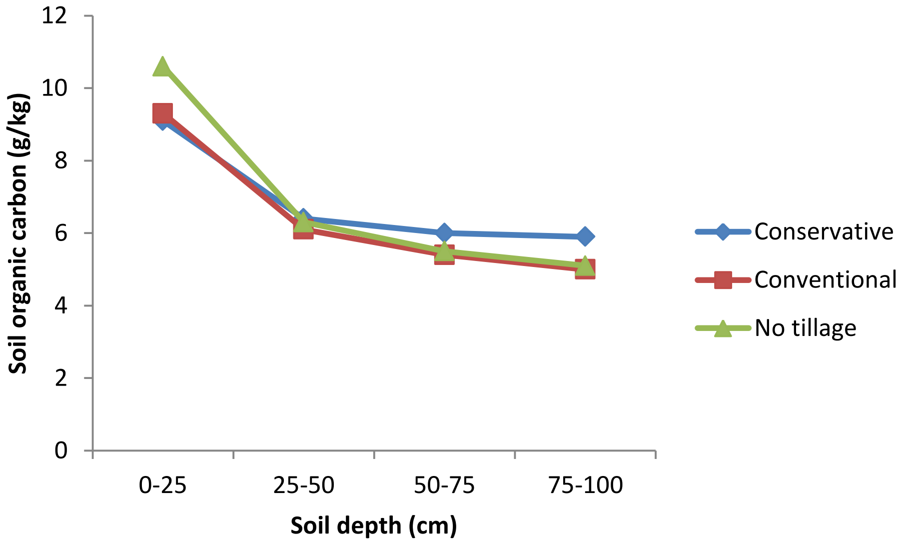

Fig. 4: Effects of Soil Depth on Soil Organic Carbon Content

3.5 Soil nitrogen (N)

From the result of soil nitrogen presented in Fig. 5, increase in soil depth decreased soil nitrogen for conventional tillage, with values of 1.5g/kg, 1.3g/kg, 1.2g/kg and 1.0g/kg for 0-25cm, 25-50cm, 50-75cm and 75-100cm soil depths respectively similar trend was not observed for no tillage (1.9g/kg, 1.9g/kg, 1.5g/kg and 1.4g/kg for 0-25cm, 25-50cm, 50-75cm and 75-100cm respectively) and conservative tillage (1.6g/kg, 1.6g/kg, 1.5g/kg and 1.3g/kg for 0-25cm, 25-50cm, 50-75cm and 75-100cm respectively). This shows that there was more organic matter accumulation with decrease in soil depths for the three tillage methods. The average soil nitrogen for conservative tillage was 1.5g/kg and 1.3g/kg for conventional tillage while an average soil nitrogen of 1.7g/kg was obtained for no tillage. Arshad *et al* 1990 and Moussa-Machraoui et al (2010) also reported more average soil nitrogen in no tillage due to high organic matter accumulation

Table 9: Effect of Tillage Methods and Soil Depths on Soil Nitrogen

Soil Depth (cm)	Soil Nitrogen(g/kg)		
	Conservative Tillage	Conventional Tillage	No Tillage
0-25	1.6	1.5	1.9
25-50	1.6	1.3	1.9
50-75	1.5	1.2	1.5
75-100	1.3	1.0	1.4
Mean	1.5	1.6	1.6

Table 10: Analysis of Variance (ANOVA) of the Effect of Tillage Methods on Soil Nitrogen

	SS	Df	MS	F	p at 0.05	Fcrit
Between	0.365	2	0.1825	4.129	0.054.2	
Within	0.3975	9	0.0442			
Total	0.7625	11				

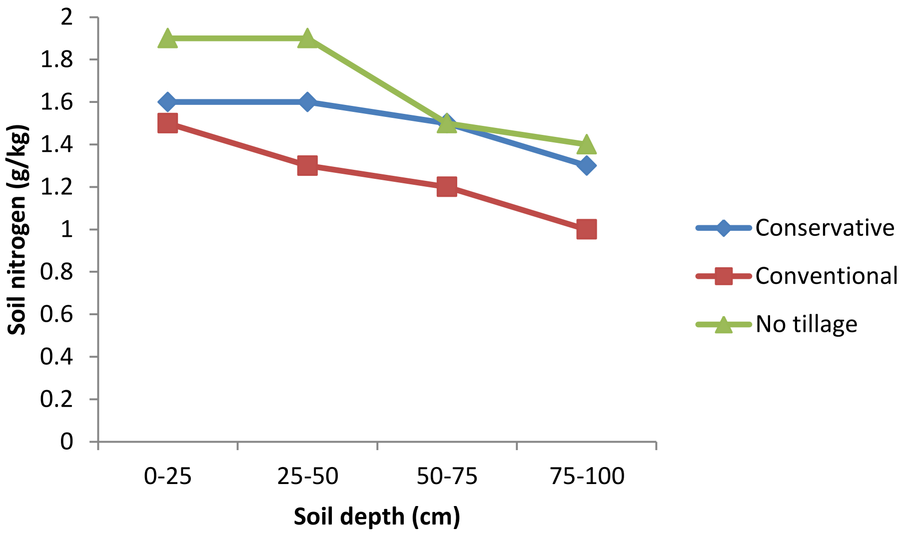

Fig 5: Effects of Soil Depths on Soil Nitrogen (g/kg)

3.6 Soil phosphorus (P)

From the result of soil phosphorous in Fig 6, increase in soil depth resulted in increase in soil phosphorus for conservative tillage, with values of 2.83mg/kg, 4.69mg/kg, 6.154mg/kg and 7.79mg/kg for 0-25cm, 25-50cm, 50-75cm and 75-100cm soil depths respectively, similar trend was also observed in conventional tillage with values of 3.095mg/kg, 3.594mg/kg, 6.045mg/kg and 6.514mg/kg for 0-25cm, 25-50cm, 50-75cm and 75-100cm soil depths respectively while different trend was observed in no tillage where values of 5.065mg/kg, 4.956mg/kg, 4.649mg/kg and 4.411mg/kg for 0-25cm, 25-50cm, 50-75cm and 75-100cm soil depths respectively. Undisturbed soil in no tillage led to accumulation of phosphorous in the upper soil layer because only little amount of mineral was allowed down the soil layer, unlike in conventional tillage and conservative tillage with less accumulation of phosphorous in the upper soil layer because of disturbance from agricultural implements. Neugschwandtner *et al.*, (2014) observed accumulation of phosphorus in the upper soil layer and depletion in deepest sampled soil layer over time

Table 11: Effect of Tillage Methods and Soil Depths on Soil Phosphorous

Soil Depth (cm)	Soil Phosphorous (mg/kg)		
	Conservative Tillage	Conventional Tillage	No Tillage
0-25	2.83	5.065	3.095
25-50	4.69	4.956	3.594
50-75	6.154	4.649	6.045
75-100	7.93	4.411	6.514
Mean	5.4	4.77	4.812

Table 12: Analysis of Variance (ANOVA) of the Effect of Tillage Methods on Soil Phosphorous

	SS	Df	MS	F	p at 0.05	Fcrit
Between	0.9953	2	0.4977	0.193	10.82	4.25
Within	23.1876	9	2.5769			
Total	24.1876	11				

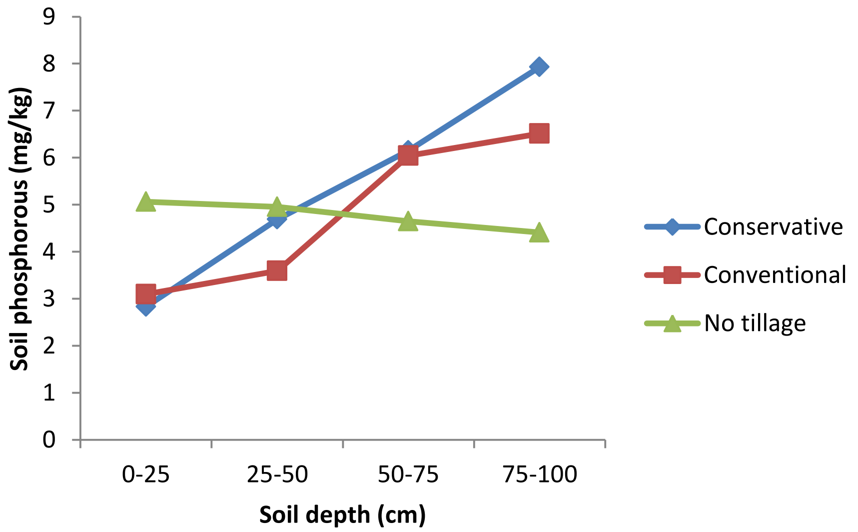

Fig 6: Effects of Soil Depths on Soil Phosphorous

4.0 CONCLUSION

The study focused on the effects of tillage methods and soil depths in south eastern Nigeria. It can be concluded that: For Soil pH, there was decrease with increase in soil depth for conservative tillage, the same trend was also observed in no tillage. A different trend was observed in conventional tillage where pH remained constant and there was a slight decrease at 75-100cm soil depth. The conservative tillage was most efficient in increasing the soil pH while the no tillage was most efficient in decreasing the soil pH.

For the soil Electrical Conductivity, increase in soil depth resulted in decrease in soil electrical conductivity for the three tillage methods. Conservative tillage is most efficient in decreasing the soil electrical conductivity, while no tillage is most efficient in increasing the soil electrical conductivity.

For soil Potassium, there was decrease in soil potassium with increase in soil depth for the three tillage methods. Conservative tillage was most efficient in decreasing soil potassium, while conventional and no tillage were the most efficient in increasing soil potassium.

For Soil Organic Carbon Content, there was reduction with increase in soil depth for the three tillage methods. Conventional tillage reduced soil organic content the most, while no tillage increased the soil organic content the most.

For Soil Nitrogen, increase in soil depth decreased soil nitrogen for conventional tillage. The same trend was not observed in no tillage and conservative tillage, where the soil nitrogen started decreasing at 50-75cm depth. This shows that there was more organic matter accumulation with decrease in soil depths for the three tillage methods. Conservative tillage was more efficient in reducing soil nitrogen, while conventional tillage was the most efficient in increasing soil nitrogen.

For Soil Phosphorous, increase in soil depth resulted in increase in soil phosphorus for conservative tillage and conventional tillage, while different trend was observed in no tillage where increase in soil depth resulted in decrease in soil phosphorous. No tillage was the most efficient in decreasing soil phosphorous, while conservative tillage was the most efficient in increasing soil phosphorous. The from the result obtained, the soil phosphorous level is low. There is need for fertilization of the soil with nutrient that is rich in phosphorous.

Soil electrical conductivity and soil nitrogen gave p values of ≤ 0.05, the other parameters gave p values greater than 0.05. This shows that the different tillage practices and soil depth resulted in significant difference in soil electrical conductivity and soil nitrogen, while tillage practice and soil depth didn't result in significant difference in soil pH, soil potassium, soil organic carbon content and soil phosphorous. Long term tillage practice could result in significance difference in these factors that are not significant. Based on the findings of this study, the following recommendations are made

- There is need for use of fertilizer rich in NPK as the nitrogen, phosphorous and potassium values obtained in the study are low.
- There is need for long term investigation of the experimental plot as there is possibility of the soil getting acidic over time due to increased pH, liming is encouraged in this situation.

REFFERENCE

APHA (1998). Standard methods for the examination of water and wastewater. 20th Edition, American Public Health Association. American Water Works Association and Water Environmental Federation, Washington DC

Arshad, M.A., Franzhi, A.J. and Azoz, R.H. (1990). Components of surface soil structure under conventional and no tillage in Northwestern Canada. *Soil Tillage Research* 53:41-47

Fabrizzi, K.P., Garcia, F.O., Costa, J.L., and Picote, L.I. (2005). Soil water dynamics, physical properties and corn wheat responses to minimum and no tillage systems in the southern Pampas of Argentina. *Soil Research,* 81. 57-69.

Kahlon, M.S. and Singh, G. (2014).Effect of tillage practices on soil physic-chemical characteristics and wheat straw yield. *International Journal of Agricultural Sciences* 4(10):289-293

Kladivko, E.J. (2001). Tillage systems and soil ecology. *Soil tillage research,* 61: 61-76

Kuzucua, M. and Dokmenb, F. (2015). The effects of tillage on soil water content In dry areas. *Agric. Agric. Sci. Procedia* 4:126-132.tgv

Neugschwandtner, R.W., Liebhard, P., Kaul, H.P. (2014). Soil chemical properties as affected by tillage and crop rotation in a long-term field experiment. *Plant soil environment,* 60 (2): 57-62

Ordonez-Morales, K.D., Cadena-Zapeta, M., Zermeno-Gonzalez, A., and Campos-Magana, S. (2019). Effectof tillage systems on physical properties of a clay loam soil under oats.

Patel, D.H. and Lakdawala, M.M. (2014). Study of soils nature by pH and soluble salts through EC of Kalol-Godhra taluka territory.*Der Chemica Sinica,* 5(2):1-7.

Patni, N.K., Masse, L. and Yui, P.J. (1998). Water quality-groundwater quality under conventional and no tillage: I. Nitrate, electrical conductivity and pH. *J. Environ Qual*. 27:869-877.

Saiful Islam, A.K.M., Saleque, M.A., Hossain, M.M. and Aminul Islam, A.K.M. (2015).Effect of conservation tillage on soil chemical properties in rice-maize cropping system. *The Agriculturists* 13(2):62-73

Wei, B., Lingwei, K., and Aiguo, G. (2013). Effects of physical properties on Electrical conductivity of compacted lateritic soil. *Journal of Rock Mechanics and Geotechnical Engineering* 5: 406-411

Zentner, R.P., Lafard, G.P., Derken, D.A., Nagy, C.N., Wall, D.D. and May, W.E. (2004). Effects of tillage method and crop rotation on non-renewable energy use efficiency for a thin black cjheruzen in the Canadian premises 77(2): 125-136