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Research Article

The short term effect of tillage on soil physicochemical properties in Bayelsa State, Nigeria

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ABSTRACT

The objective of the research was to determine the effect of different tillage methods on some soil physicochemical properties in Niger Delta University Teaching and Research Farms. The land was divided into plots measuring 5 x 5 m with three replicates per treatment. Five tillage treatments considered were: No Till, hoeing, digging, hoeing + digging once, and hoeing + digging twice. Two samples were collected per plot at 0-15 cm and 15-30 cm depth. A total number of thirty (30) samples were collected from the field. The research was laid out using the Randomized Complete Block Design. Results showed that the tillage methods had no significant effect on the soil's chemical properties but influenced the physical. Mean pH across all plots ranged from 4.42 – 4.49 indicating strongly acidic state, electrical conductivity ranged 65.67-82 dS m^{-1} indicating no salinity stress, detrimental to crops; organic carbon and organic matter were moderate with a range of 18.52-21.55 g kg^{-1} and 37.03-43.10 g kg^{-1} respectively. Total nitrogen was at its moderate range of 7.88-12.17 g kg^{-1}. Exchangeable acidity was low with a range of 1.52-1.71 cmol kg^{-1}. The tillage methods influenced soil bulk density and porosity; the highest bulk density was recorded in the NT zone (1.18 g cm^{-3}) which decreased steadily with an increase in tillage intensity. With the hoe+digging (twice) recording the lowest value of 0.94 g cm^{-3}. Similarly, the highest porosity value was found in the tillage method with the lowest bulk density value (0.94 g cm^{-3}: 64.7%), while the lowest was observed in the tillage method with the highest bulk density value (1.18 g cm^{-3}: 55.7%). pH had positive correlation ($P<0.05$) with electrical conductivity (r=0.62), organic carbon (r=0.94), organic matter (r=0.90), and negative correlation with exchangeable acidity (r=-0.52). Organic carbon had strong positive correlation with organic matter (r=0.99), effective cation exchange capacity (r=0.69), clay (r=0.50), and total nitrogen (r=0.61). Silt (r=0.74) and clay (r=0.70) showed positive relationship with bulk density, while bulk density (r= -0.99) showed strong negative correlation with porosity. It is therefore recommended that crude tillage methods be used for sustainable and conservative agriculture.

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1. Introduction

There are several definitions of tillage. According to Lal et al. (2007), it is defined as physical, chemical or biological soil manipulation to optimize conditions for germination, seedling establishment and crop growth. Tillage is the mechanical manipulations of soil to make it favorable for plant growth eliminating weeds during the growth of the plant (Sahay, 2008). Tillage affects the physical, chemical, and biological properties of soils as observed from research results on soils in several parts of Africa where it was seen to affect soil aggregate, temperature, water infiltration, and retention (Ofori, 2009).

Tillage systems are often divided into two types: conservation tillage and conventional tillage (Mohammed and Umogbai, 2014). Reduced soil compaction, economically viable crop rotations, and the creation of surface residue cover are three key components of conservation agriculture (Kienzler et al., 2012), which ensure long-term crop productivity while reducing environmental concerns (Valbuena et al., 2012). Conservation tillage is now used on an estimated 125 million hectares, or about 9% of the world's arable land (Kassam et al., 2012). Over several decades, the conservation agricultural system was reviewed and applied in several climatic regions around the world, including the tropical, subtropical, and temperate zones. Conservation tillage leaves at least 30% of crop residue on the soil surface, which equates to at least 1.100 kg ha^{-1} of small grain residue (Mohammed and Umogbai, 2014).

Soil tillage is among the important factors affecting soil's physical, chemical properties and crop yield. Among the crop production factors, tillage contributes up to 20% (Khurshid et al., 2006). Tillage method affects the sustainable use of soil resources through its influence on soil properties (Alvarez and Steinbach, 2009). Jabro et al. (2016) reported that tillage depth and intensity alter the soil's physical and chemical properties that affect plant growth and crop yields.

The proper use of tillage can improve soil-related constraints, while improper tillage may cause a range of undesirable processes, e.g. destruction of soil structure, accelerated erosion, depletion of organic matter and fertility, and disruption in cycles of water, organic carbon, and plant nutrient. The use of excessive and unnecessary tillage operations is often harmful to the soil. It has been observed that more tillage is being done than necessary leading to soil loss by wind and water erosion. In some instances, too many passes of tractor machine aggregate lead to the formation of soil pan thereby reducing air and water infiltration and circulation. Therefore, currently, there is a significant interest and emphasis on the shift to conservation and NT age methods to control the erosion process (Costa et al., 2015). This study aims to assess the impact of Tillage on Soil Physico-Chemical Properties in Niger Delta University Teaching and Research Farm, Bayelsa State, Nigeria, and to determine the correlation coefficient between some physical and chemical properties of the soil under the different tillage methods. The tillage implements and methods were considered because they have been used by subsistent farmers in Bayelsa State for decades without scientifically researching their impact to soils.

2. Materials and methods

2.1. Study area

The study was carried out in the Niger Delta University Teaching and Research Farm, located in Amassoma Community, Southern Ijaw Local Government Area in Bayelsa State. It lies within 4058'47.85" N and 606'19.51" and is situated in the southern part of the Niger Delta of Nigeria. In Amassoma, the wet season is warm and overcast, the dry season is hot and mostly cloudy, and it is year-round. For the year, the temperature typically varies from 21°C to 30°C and is rarely below 17°C or above 32°C. Average annual rainfall of the study region is 2,250 mm. The topography doesn't change. Shrubs found in the area include elephant grass (*Pennisetum purpureum* L.), *Jatropha tanjorensis* Ellis &Saroja, Costus afer Ker Gawl, Goat weed (*Ageratum conyzoides* L.). Other trees found in the area include plantain (*Musa paradisiaca* L.), oil palm (*Elaeis guineensis* Jacq.) etc. Sandy loam and sandy clay loam were the predominant surface and subsurface textures in the NT zone. In the hoed area, the digging zone, and the H+D (1) zone, it ranged from loamy sand to sandy loam, and in the H+D (2) zone, it ranged from sandy loam to loamy sand.

2.2. Field layout

The research field was carried out was divided into five treatment plots of 5 x 5 m and three replicates with a walkway of 1m. The five conservational tillage methods (No till (NT), hoeing, digging, hoeing + digging once (H+D 1) and hoeing + digging twice –H+D 2) were carried out in each plot with the aid of a hoe (20 x 20 cm blade) and digger (30 cm length), to the depths of 0-15 cm and 15-30 cm. The area for the experiment was a land kept aside for student research and had not been tilled before hand. The tillage practices were completed within an interval of one week. The soil texture of the area is mainly coarse textured, inherently from the parent material found in the region.

Plate 1. Tillage implements utilized for the research

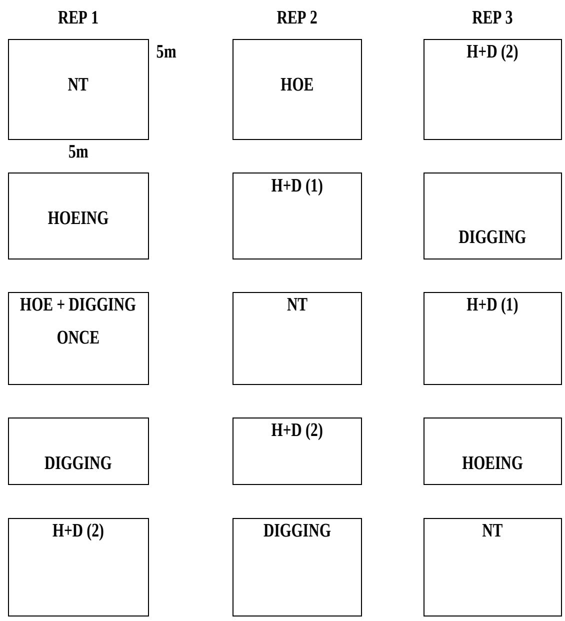


Figure 1. Experimental layout of the study site

2.3. Sample collection

Soil samples were taken from the 0-15cm and 15-30cm depth with the use of a soil auger. Two samples were collected per plot with a total of thirty (30) samples from the field. Each sample was put into a clean polythene bag and then properly labeled with an indelible marker. The samples were transferred to the Soil Science Laboratory where they were air dried, crushed, and passed through a 2mm sieve. The air-dried samples were analyzed to determine pH, electrical conductivity, organic carbon, organic matter, total nitrogen, exchangeable acidity, Na, K, Ca, Mg, available P, cation exchange capacity, effective cation exchange capacity, and base saturation.

Soil cores were used to take samples for bulk density and porosity. The core was carefully hammered into different depths using a block of hardwood, after the different tillage exercises. Excess soil was then cut off using a knife to create equilibrium between the soil column and the core.

2.4. Laboratory analysis

Soil pH and electrical conductivity were determined in a soil-water medium at a ratio of 1:1 using Coleman's pH and EC meter. Particle size analysis was carried out using the hydrometer method according to the method of Bouyoucous (1962). Soil organic carbon (SOC) was determined by the Walkley and Black (1934) procedure according to Nelson and Sommers (1996); Soil organic matter was estimated as organic carbon multiplied by 1.724. Exchangeable cations, Ca, Mg, K and Na were extracted with 1N ammonium acetate solution (1N NH4OAc) buffered at pH 7.0 the Ca and Mg were determined from the extract using 0.01m EDTA (ethylenediaminetra-acetic acid) titration method as described by Black (1965), while K and Na were determined using flame photometer (Jackson, 1962). Total nitrogen was determined using the regular micro Kjeldahl method as reported by Bremmer and Mulvaney (1982). Available P was determined by Bray's P1 method (Bray and Kurtz, 1945) and read on the atomic absorption spectrophotometer, while exchangeable cations (K, Ca, Na and Mg) were first extracted using the method of Jackson (1962), thereafter, K, Na and Ca were determined by the flame photometer while Mg was read from the Atomic Absorption Spectrophotometer (AAS). The titration method was used to determine exchangeable acidity as described by McLean (1982). Soil bulk density in two layers was determined using the core method. The soil samples were randomly taken per plot using a stainless teel core sampler. The collected soil cores were trimmed to the exact volume of the cylinder and oven dried at 105 °C for 24 h. Precautions were taken to avoid compaction inside the core sampler. The bulk density was determined from the ratio of the mass of dry soil per unit volume of soil cores (Aikins and Afuakwa, 2012).

$$\text{Bulk density} = \frac{mass\ of\ oven\ dried\ soil\ (g)}{total\ volume\ of\ soil\ (cm^3)}$$

The total porosity was calculated from the values of the bulk density and an assumed particle density of 2.65 g cm^{-3} using the following Equation (Aikins and Afuakwa, 2012).

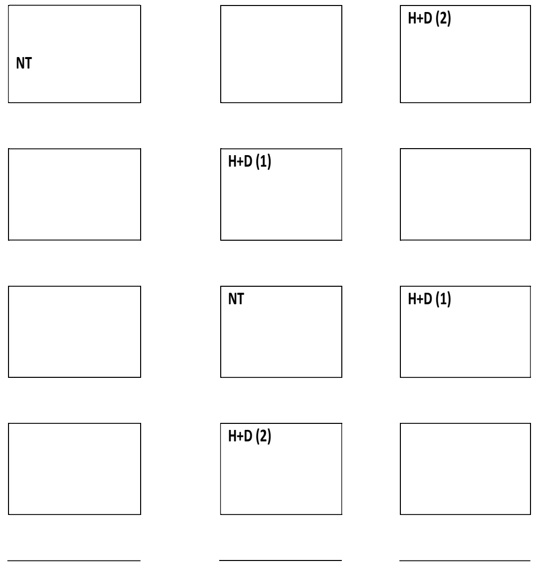
$$TP = 1 - \left(\frac{Bulk\ density}{particle\ density}\right) \times 100$$

2.5. Experimental design and statistical analysis

Randomized Complete Block Design (RCBD) was used to arrange the experiment. Analysis of variance (ANOVA) was conducted on the collected data to check the differences between the treatments. Duncan Multiple Range Test on a grand mean data at the 5% level of probability (p<0.05) based on the F-test of the analysis of variance was used to determine the difference in the means, while correlation analysis was carried out to check the relationship between some physical and chemical properties.

3. Results and discussion

Table 1 contains the values of some physical and chemical properties of the soils and their effects under the considered crude tillage practices.



3.1. pH

Both surface and subsurface soils under the no till (NT) zone had very acidic pH values (4.33). The surface and underlying soils remained very acidic after hoeing (4.60 and 4.37). Digging (D) had no discernible impact (P <0.05) on soils with pH values of 4.30 and 4.40, either on the surface or below. The pH remained significantly acidic (4.37 and 4.47) at both levels despite [H+D (1)] having no significant impact (P<0.05). Additionally, (H+D (2) had no discernible impact on the soils' pH status in the surface and subsurface zones, which were 4.20 and 4.63 respectively.

According to Table 1, there was no discernible difference in the pH of the soil when the amount of tillage was increased (NT, hoe, digging, H+D (1), and H+D (2). The University's Teaching and Research Farm's soils are regularly cultivated by students for academic, practical, and research purposes, which "may" be the cause of the low pH. The heavily acidic condition of the soils can be linked to high cropping intensity, which caused the crops to absorb most of the basic cations, and excessive rainfall, which causes the basic cations in the soil to leach (Nta et al., 2017).

3.2. Electrical conductivity (EC)

The EC was 0.094 dS m^{-1} at the surface soil and 0.062 dS m^{-1} at the subsurface soil following hoe use. After digging, the EC at the surface and subsurface soils was 0.065 dS m^{-1}. The surface soil at the H + D (1) practice had an EC of 0.083 dS/m, while the subsurface soil had an EC of 0.081 dS m^{-1}. After twice hoeing and digging, the soil's subsurface EC was 0.078 dS m^{-1} and the surface EC was 0.070 dS m^{-1}. The average values for the five tillage methods revealed that the H + D (1) site had the greatest EC value of 0.082 dS m^{-1} and the H + D (2) zone had the lowest (0.074 dS m^{-1}). All five tillage methods had electrical conductivities below 4, which indicated that neither soil structure aggregation nor saline restriction to root and seed sprouting existed (Ganjegunte et al., 2018).

3.3. Organic carbon and organic matter

Organic carbon content of the surface and subsurface soils in the NT zone ranged from 16.43 to 21.53 g kg^{-1}, with a mean of 18.98 g kg^{-1}. The organic matter concentration in the surface and subsurface soils of the NT Zone ranged from 32.87 to 43.07 g kg^{-1}, with a mean of 37.97 g kg^{-1}. Surface and subsurface values during hoeing were 49.73 and 36.47 g kg^{-1} respectively, with a mean of 43.10 g kg^{-1}. H+D (2). The outcome demonstrates that none of the tillage methods had a significant impact ($P<0.05$) on organic carbon and organic matter (Table 1). Under the tillage methods, the organic matter was of an amount. Despite frequent use, the moderate level of organic carbon and organic matter could be attributable to students' gradual application of organic manure for crop production. Heavy tillage machinery can excessively widen soil pores (Szostek et al., 2022), facilitating the illuviation of organic materials and clay to the subsoils under heavy rains. Therefore, the light mechanical structure of the rudimentary implement as compared to heavy-duty machinery was the cause of the steady, immutable nature of the organic carbon and matter (Nta et al., 2017).

3.4. Total nitrogen

The average total nitrogen for NT, digging, hoeing, H+D (1) and H+D (2) was 8.87, 12.17, 11.63, 7.88, and 10.87 g kg^{-1} respectively (Table 1). The average mean separation demonstrates that the tillage methods had no appreciable impact on total nitrogen. Since the total nitrogen and organic carbon are correlated, the moderate state of the total nitrogen under the various tillage methods results from this (Brady and Weil, 2005).

3.5. Exchangeable acidity

With 1.65 and 1.76 cmol kg^{-1} at the surface and subsoil of the NT, exchangeable acidity was low. When hoeing, the values were 1.50 (surface) and 1.60 (subsurface), 1.50 and 1.70 (after digging), 1.59 and 1.63 (hoeing and digging), and 1.41 and 1.63 (hoeing and digging twice). There was no significant difference between the two depths for any of the five tillage methods at $P<0.05$.

In the cases of NT, Hoeing, Digging, H+D (1), and H+D (2), the mean exchangeable acidity was 1.71, 1.55, 1.60, 1.61, and 1.52 cmol kg^{-1}, respectively. The results showed that there were no significant differences between results, indicating that the use of crude tillage implements at higher intensities had no impact on the soil's exchangeable acidity (Table 1). The higher organic matter preceded the low exchangeable acidity.

There were no appreciable differences in Na levels across the five-tillage method. The methods supported it further by obtaining results of 0.21 cmol kg^{-1} in the NT area, 0.19 cmol kg^{-1} while hoeing, 0.13 cmol kg^{-1} when digging, 0.28 cmol kg^{-1} when H+D (1), and 0.20 cmol kg^{-1} when H+D(2). With averages of 0.51, 0.33, 0.24, 0.62, and 0.54 cmol kg^{-1} under NT, hoeing, digging, H+D (1), and H+D (2), respectively, a similar trend was seen in the K values.

However, the results demonstrate that the mean calcium (Ca) levels at the NT, H+D (1), and H+D (2), as well as hoe (0.80 cmol kg^{-1}) and digging (0.55 cmol kg^{-1}), were identical.

The decline in Ca upon tillage could be attributed to disintegration of soil particles and leaching of bases by rainfall. This would inevitably cause a reduction in Ca availability. Also, Mg indicated significant difference ($P<0.05$) with H+D (1) - 1.51 cmol kg^{-1} and H+D (2) - 1.21 cmol kg^{-1} at the NT, Hoeing (0.50 cmol kg^{-1}), and digging locations. This finding suggests that increasing tillage techniques may decrease the availability of magnesium (Agbede and Ojeniyi, 2009).

3.6. Bulk density

The average bulk density was 1.17 g cm^{-3}, 1.07 g cm^{-3} in the hoeing zone, 1.09-1.12 g cm^{-3} in the digging zone, 0.92-1.0 g cm^{-3} in the H+D (1) zone and 0.90 – 0.98 g cm^{-3} in the H+D (2) Zone.

The mean values showed that the crude tillage methods had a significant effect on the bulk density. There was a steady decline in bulk density values with increasing intensity of the tillage practices. NT registered the highest mean bulk density of 1.18 g cm^{-3}, hoe (1.07 g cm^{-3}), digging (1.11 g cm^{-3}), H+D (1) (0.96 g cm^{-3}), while the lowest was found in the H+D (2) zone (0.94 g cm^{-3}). There was no significant difference between the bulk density of hoeing and digging, and between H+D (1) and H+D (2). Additionally, the results showed that hoeing and digging had no impact ($P<0.05$) on bulk density, as was also observed between H+D (1) and H+D (2). The bulk densities of the "methods" of all the different tillage techniques fell below the critical criterion of 1.80 g cm^{-3} (Weil et al., 2016). The result in Table 1 shows that increased tillage methods can affect soil bulk density, i.e., that bulk density decreases as tillage methods are increased (Agbai and Kosuowei, 2022).

3.7. Soil porosity

Porosity was inversely related to the measured bulk densities. The following porosity values were detected as a result of decreasing bulk density values: NT (55.7%), hoe (59%) and digging (58.4%), H+D (1) (63.9), and H+D (2) (64.7). The increased tillage methods damaged the soil's structure, increasing the amount of pore space. The maximum porosity values were recorded by H+D (1) and H+D (2), while the lowest values were found in the NT zone. Elder and Lal (2008) found that tilled plots had higher overall porosity than no-tillage plots for organic soils.

3.8. Correlation matrix

Table 2 shows the correlation between some physical and chemical properties. Soil pH correlated positively with EC, OC, OM and negatively with EA (r=0.62), organic carbon (r=904), organic matter (r=0.905), and negative correlation with exchangeable acidity at r = -0.522. An increase in organic matter and carbon caused an increase in pH and electrical conductivity of the soils while an increase or decrease in pH caused a decline or increment in effective cation exchange capacity.

Organic carbon showed strong positive correlation with organic matter at r=0.99, Effective Cation Exchange Capacity (r = 0.697), clay (r = 0.502), total nitrogen at r = 0.607, and negative relationship with exchangeable acidity at r=-0.819. Organic matter showed a similar positive correlation with organic matter, effective cation exchange capacity, clay, and total nitrogen; with exchangeable acidity exhibiting the negative correlation. This result indicates that as organic matter increases so will total nitrogen (Brady and Weil, 2005). Total nitrogen was negatively correlated with exchangeable acidity at r = -0.601. Effective cation exchange capacity showed negative correlation with sand and silt at r = -0.678 and -0.509 and positive correlation with clay, bulk density and porosity (r = 0.888, 0.508 & 0.698). A decrease in effective cation exchange will cause a decrease in the availability of total nitrogen in the soil. As clay increases, there is an inverse movement in the relative proportion and sand; which further significantly increases effective cation exchange capacity, bulk density, and porosity.

Silt and clay showed positive correlation with clay and bulk density with a correlation index at r= 0.737, 0.705, while bulk density negatively correlated with porosity with r = -0.995. The result showed that bulk density and porosity are inversely proportional to one another; therefore, an increase in bulk density will amount to a decrease in porosity.

4. Conclusion

The research showed that the tillage methods had no significant effect on soil chemical properties such as pH, electrical conductivity, organic carbon, organic matter, total nitrogen, and exchangeable acidity. It further showed that intrinsic soil properties like texture cannot be easily changed by mechanical implements over a short time. However, physical parameters such as bulk density and porosity were significantly impacted by the intensification of the tillage methods. It was therefore observed that tillage implements can significantly impact soil physical characteristics but have no significant effect on their chemical characteristics.

From the results discussed, it is therefore recommended that crude tillage implements such as hoe and diggers can be used in the practice of conservative and sustainable agriculture in Niger Delta University Teaching and Research Farm.

Compliance with Ethical Standards

The authors declare that there is no conflict of interest.

Authors' Contributions

Agbai Williams Perekekeme: Validation, Investigation, Writing - original draft, Methodology, Conceptualization. **Joseph Oyinbrakemi Tate**: Review and editing. Validation, Formal analysis, Data curation

Ethical approval

Not applicable.

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Data availability

Not applicable.

Consent for publication

We humbly give consent for this article to be published

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Table 1. Physical and chemical properties of the soils under different crude tillage measures

TRTS	depth	pH	EC	Org.C	Org.M	TN	EA	Na	K	Ca	Mg	Av.P	ECEC	Sand	Silt	Clay	Texture	BD	POR
			dS m^{-1}		g kg^{-1}					cmol kg^{-1}					g kg^{-1}			g cm^{-3}	%
NT	0-15cm	4.33a	75.67a	16.43a	32.87a	6.30a	1.65a	0.19a	0.48a	1.20a	0.93a	1.97b	4.47a	615	144.4	240.6	Sandy loam	1.17a	56.0a
	15-30cm	4.43a	77.00b	21.53b	43.07b	11.43b	1.76a	0.23a	0.54a	1.25a	0.96a	1.24a	4.73a	655	124.4	220.6	Sandy Clay loam	1.18a	55.3a
Mean		**4.38A**	**76.34C**	**18.98A**	**37.97A**	**8.87B**	**1.71A**	**0.21A**	**0.51A**	**1.23B**	**0.95A**	**1.61B**	**4.60C**	**635**	**134.4**	**230.6**	**Sandy loam**	**1.18C**	**55.7A**
Hoe	0-15cm	4.60a	93.67b	24.87b	49.73b	14.63b	1.50a	0.25b	0.42a	1.03b	0.66a	0.39a	3.87b	855	64.4	80.6	Loamy sand	1.06a	59.9a
	15-30cm	4.37a	61.67a	18.23a	36.47a	9.70a	1.60a	0.12a	0.24b	0.56a	0.34a	0.23a	2.87a	695	114.4	190.6	Sandy loam	1.07a	59.5a
Mean		**4.49A**	**77.67C**	**21.55B**	**43.10B**	**12.17E**	**1.55A**	**0.19A**	**0.33A**	**0.80A**	**0.50A**	**0.31A**	**3.37B**	**775**	**89.4**	**135.6**	**Loamy sand**	**1.07B**	**59.0B**
Digging	0-15cm	4.30a	65.67a	17.57a	35.13a	10.93a	1.50a	0.12a	0.24a	0.56a	0.45a	0.28a	2.87a	735	114.4	120.6	Loamy sand	1.09a	59.0a
	15-30cm	4.40a	65.67a	19.47b	38.93b	12.33b	1.70a	0.13a	0.24a	0.53a	0.46a	0.32a	3.07b	745	84.4	170.6	Loamy sand	1.12a	57.7a
Mean		**4.35A**	**65.67A**	**18.52A**	**37.03A**	**11.63A**	**1.60A**	**0.13A**	**0.24A**	**0.55A**	**0.46A**	**0.30A**	**2.97A**	**740**	**99.4**	**145.6**	**Loamy sand**	**1.11B**	**58.4B**
H+D (1)	0-15cm	4.37a	82.67b	18.03a	36.07a	6.13a	1.59a	0.29a	0.63a	1.52a	1.14a	2.52a	5.20a	855	64.4	80.6	Loamy sand	0.92a	65.4a
	15-30cm	4.47a	81.33a	23.40b	46.80b	9.63b	1.63a	0.27a	0.61a	1.50a	1.18a	2.32a	5.20a	735	94.4	170.6	Loamy sand	1.00a	62.4a
Mean		**4.42A**	**82D**	**20.72B**	**41.44B**	**7.88A**	**1.61A**	**0.28A**	**0.62A**	**1.51B**	**1.16B**	**2.42C**	**5.20D**	**795**	**79.4**	**125.6**	**Loamy sand**	**0.96A**	**63.9C**
H+D (2)	0-15cm	4.20a	70.00a	20.53b	41.07b	11.73b	1.41a	0.21a	0.47a	1.19a	1.14a	1.10a	4.40a	695	124.4	180.6	Sandy loam	0.90a	66.2a
	15-30cm	4.63a	78.00b	17.83a	35.67a	10.00a	1.63a	0.19a	0.60b	1.37a	1.28a	1.46b	5.13b	735	144.4.	120.6	Loamy sand	0.98a	63.1a
Mean		**4.42A**	**74B**	**19.18A**	**38.37A**	**10.87C**	**1.52A**	**0.2A**	**0.54A**	**1.28B**	**1.21B**	**1.28B**	**4.77C**	**715**	**134.4**	**150.6**	**Loamy sand**	**0.94A**	**64.7C**

Letters a, b and c depict similarities or differences at the different depths while A, B, and C represent similarities or differences of the depth means. Value(s) with the same letters(s) in the column are not significantly different from one another at a 5% level of probability in each tillage methods using Duncan Multiple Range Test. EC – Electrical Conductivity, Org. C – Organic carbon, Org.M – Organic Matter, TN – Total Nitrogen, EA – Exchangeable acidity, Na – Sodium, Ca – Calcium, Mg – Magnessium, Av. P – Available Phosphorus, ECEC – Effective Cation Exchange Capacity, BD – Bulk Density, POR - Porosity

Table 2. Correlation Matrix of selected physical and chemical properties

	pH	EC	Org.C	Org.M	TN	EA	ECEC	Sand	Silt	Clay	BD	POR
pH	1											
EC	0.623*	1										
Org. C	0.904	0.728	1									
Org.M	0.905	0.729	0.999**	1								
TN	0.244	-0.204	0.617	0.616	1							
EA	-0.522	0.094	-0.819	-0.885	-0.601	1						
ECEC	0.268	0.478	0.697	0.648	0.397	0.255	1					
Sand	0.482	0.2442	0.364	0.362	0.147	-0.598	-0.678	1				
Silt	-0.329	-0.259	0.252	-0.349	0.001	0.192	-0.509	-0.887	1			
Clay	-0.410	-0.065	0.502	-0.699	-0.286	0.769	0.888**	-0.957	0.737	1		
BD	-0.371	-0.349	-0.313	-0.393	0.116	0.721	0.508	-0.596	0.214	0.705	1	
POR	0.282	0.3117	0.229	0.289	-0.163	-0.679	0.698	0.551	-0.171	0.669	-0.995	1

EC – electrical conductivity, Org.C – organic carbon, Org.M – organic matter, TN – total nitrogen, EA –exchangeable acidity, ECEC – effective cation exchange capacity, BD – bulk density, POR - porosity

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