Characterization of soil properties, nutrient distribution and Rice (*Oryza sativa.)* productivity as influenced by tillage methods in a typical *gleysols*

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Abstract

Global emphasis and interest in conservation Tillage in agricultural soils has tremendously increased in the last few years, especially no tillage with its potential to improve soil physicochemical properties, reduce nutrient leaching as well as improve crop productivity in a more sustainable manner. Several questions still exist with regard to the true role of no tillage in improving soil fertility. A two year field study was conducted to characterize the effects of different tillage methods on soil surface physical, chemical properties and nutrient movement across the soil profile of gleysols, developed over granite. In all, Five tillage methods namely; No tillage direct seeding(NTDS), No tillage transplanting(NTTS), Minimum tillage direct seeding(MTDS), minimum tillage transplanting(MTTS) and Conventional tillage(CT) were studied in a Randomized Complete Block Design (RCBD) with three replications each. After two cropping seasons, the highest bulk density, penetration resistance and lowest porosity were in the order of (NTTS=NTDS) > MTTS > MTDS > CT for both 2016 and 2017 cropping seasons. Results also indicated that though all tillage methods had positive effect on nutrient levels at the surface (0-20cm), NTDS and NTTS recorded high levels of nutrient compared to the rest of the treatments. However, compared with the rest of the treatments, CT was characterized by high incidence of nutrient movement (leaching) along the soil profile (0-100cm). Subsequently, highest plant height and Stover yield (t/ha) were in the order of CT > NTTS > NTDS > MTTTS > MTDS. There was no significant difference in grain yield(t/ha) of rice for both CT and NTTS for 2016 and 2017 cropping seasons even though NTTS had a slight increase in yield over CT in 2016. Results from this study suggest that even though tillage method tended not to affect nutrient levels so much, the different land preparation methods significantly affected nutrient distribution and grain yields. NTTS produced rice grain yield comparable to CT and NTDS under the prevailing conditions. However, considering the high levels of nutrient movement associated with CT compared to NTTS and also the cost of land preparation and other environmental problems associated with CT, NTTS is recommended for farmers in Ghana to ensure high and sustainable production to feed the growing population.

Keywords. *Tillage methods, soil properties, Nutrient leaching, Rice growth*

1. Introduction

Increasing population and the development of agricultural land requires maximum land utilization and sustainable agricultural operations (Javanshir *et al* 2004). Agricultural mechanization and intensive and continuous tillage operations over the decades have led to soil degradation, declining fertility and increasing soil salinity(Niu and Wang 2002).Some of these land preparation methods include conventional tillage(CT) (that employs the use of disc ploughs, disc harrows, rotovators, chisel ploughs), minimum tillage(MT) (that involves the use of bullock drawn implements, traditional cutlass and hoe) and No tillage (NT)(which mostly relies on the use of spray chemicals). A difference in management practices often result in differences in biological, chemical and physical properties of soil which in turn, result in changes in functional quality of soil(Derpsch *et al* 2010 and Ding *et al* 2011). Inappropriate land uses and management systems lead to soil erosion, depletion of organic matter and other nutrients which results to permanent soil degradation and productivity losses (Ramos et al 2011). The frequency and intensity of tillage practices is said to alter soil properties, distribution of nutrients, as well as soil organic matter status in the soil profile, with a resultant reduction in soil quality (Blevin and Frye 1993). The extent of change will depend largely on the type of tillage measures adopted, climate, soil and farm management practices in any given farm situation. These tillage effects, however, are environmentally dependent and different results have been reported under different types of soil and climate (Limousin and Tessier 2007 and Thomas *et al* 2007). Different authors have reported clear benefits in soil physical properties associated with the use of zero tillage (Franzluebbers 2002a). Any management practice imposed on soil for altering the heterogeneous body may result in generous or harmful outcomes (Derpsch *et al* 2010). Reducing disturbance of soil by reduced tillage influences several physically (Lopez-Garrido *et al* 2012), chemically (Page et al 1998), and biologically interconnected properties of the natural body.

Even though, all the above mentioned tillage methods help to establish crops on the field, each method directly or indirectly presents some challenges to the farmer as far as soil nutrient and water management are concern. Soil tillage is among the most important factors affecting soil nutrient levels, distribution and movement across various soil profile. However, most farmers in Ghana are not aware of the linkage between inappropriate tillage and water management practices on one hand and environmental degradation on the other. In order for agricultural production to be sustainable and sufficient to meet the demands of the ever-growing population in the country and the world at large, the impact of climate change must be understood and integrated into agricultural sector activities. One effective way of doing this, is the introduction of improved technologies including land management practices. In order to achieve sustainable agriculture, soil management techniques like different tillage systems (reduced tillage or no tillage) are designed as practical means (Koochaki *et al* 1997). Ghana has an agrarian economy and as such sustainable land management is a prerequisite for sustainable and enhanced production, improved food security, and increased incomes and livelihoods, for its present and future generations. However, land degradation has been and continues to be a major threat to crop production. Within the country, land degradation, desertification and soil erosion hit hardest at the local level and those affected are small scale peasant farmers who account for over 80% of domestic production. According to the Ministry of Food and Agriculture (MoFA)

(MoFA 2010), the country produces only 51% of its cereal needs. Rice (Oryza sativa) is one of the staple food crops in the country but yield of the crop is relatively low. MoFA further describes growth in agriculture as slow and attributed this to poor technology development and dissemination under poor soil conditions. Even though there is an increase in the commercial production of rice, higher production figures are more related to higher acreages rather than higher yields per unit area. This has compelled most famers to adopt various land preparation methods to provide a conducive environment that will not only be suitable for optimum maize growth and yield but environmentally sustainable.

Over the years, there has been many research works done on tillage in Ghana but very little work has been done on the effect of different tillage methods on soil physical and chemical properties, nutrient movement and distribution along the soil profile as well as the effect of such tillage methods on rice (*Oryza sativa)* productivity. Agricultural management practices have been reported to affect soil physical, chemical, and biological properties with consequences for the movement of water, nutrients, and pollutants in the rooting zone (Strudley *et al* 2008). This study was therefore conducted to characterize soil physical and chemical properties, nutrient movement and distribution across the soil profile as well as the growth and yield of rice(*Oryza sativa*) as influenced by tillage methods on a *greysol* in the forest agro-ecological zone of Ghana.

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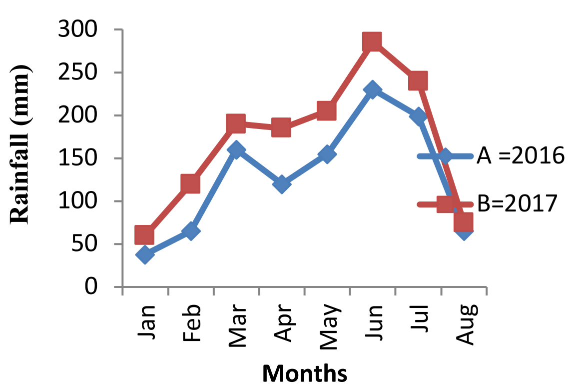
2. Materials and Methods

2.1 Location and climatic conditions of Study Area

The study was conducted at the arable fields of the Kwadaso College of Agriculture (6°40’25.6"N, 1°40’40.3"W,), Kumasi-Ghana. The field study was conducted over a two year period from April, 2016 to April, 2017 during the major growing seasons on an experimental field established five years ago. The soil is gleysols, developed over granite. The area is characterized by two (2) growing seasons; a major rainy season (April to July) and a minor rainy season (September to October). The month of August experiences a short dry spell. Temperature varies between 26^{o}C and 34^{o}C. The area is scattered with shrubs and a few trees which normally shed their leaves during the dry season (October – March).The monthly rainfall and average temperature values are shown in figure 1 below.



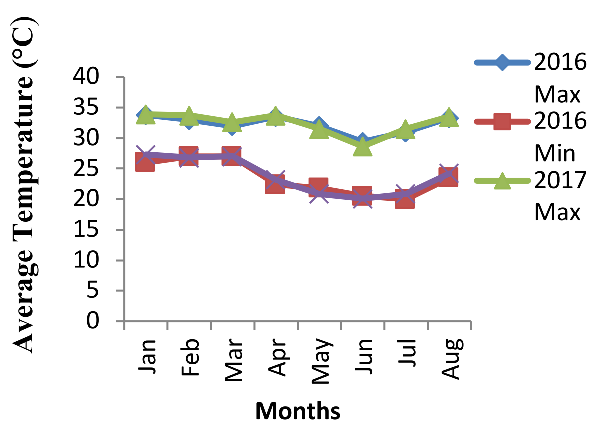


Fig.1 Average monthly temperature and rainfall figures of Experimental site during the 2016/2017 growing seasons

The experimental site covered a total area of 6600m^2. A Randomized Complete Block Design (RCBD) was used with five treatments representing a block and replicated three times. The treatments were, No tillage direct seeding(NTDS), No tillage transplanting(NTTS), Minimum tillage direct seeding(MTDS) involving a power tiller mounted rotovator at a depth of 8cm, minimum tillage transplanting(MTTS) involving a power tiller mounted rotovator at a depth of 8cm and conventional tillage(CT) involving a power tiller mounted rotovator at a depth of 25cm. Each treatment plot measured 10m × 40m and had a population of10, 000 plants per plot at a spacing of 20cm x 20cm. Jasmine 85 was used as the test crop in both seasons with two seedlings per hole.

2.3 Soil Sampling and analyses

Soil samples were collected using both soil auger and cores for both 2016 and 2017. Soil samples were collected at harvest in 2016 and 2017. Composite soil samples for each treatment were collected at depths of 0-20cm, 20-40cm, 40-60cm, 60-80cm and 80-100cm during both years. The soil samples were then air dried for 4-5 days, sieved into various sizes of 2mm, 1mm and 0.15mm for further analysis.

2.2.1 Soil physico-chemical Properties

The soil bulk density (g cm^{-3}) was estimated by using the core method (Blake, 1965). Soil penetration resistance (kPa) was measured using Penetrometer (TYD-2). Soil percentage porosity was calculated as:

Percentage porosity, $P(\phi) = 1 - (Bulk\ density/particle\ density) \times 100$

Soil pH was measured using a glass electrode (pH meter) in a soil to water ratio of 1:2.5(IITA 1979). Soil organic carbon (SOC) was determined by the (Walkley and Black 1934). Total nitrogen was estimated by the macro-Kjeldahl wet oxidation method (Bremner and Mulvaney, 1982). Exchangeable K was determined using flame photometry. Available phosphorus (P) was determined by the Bray-1 method (Bray and Kurtz 1945). Nitrate-N (NO_3-N) and ammonium-N (NH_4-N) were extracted using 2.0-M KCl, and determined using Skalar SA 5000 analytical instrument.

2.2.2 Growth and yield parameters of rice

At maturity, a 1m^2 area excluding border rows was measured out in each sub-plot, number of panicles counted and harvested. Grain and Stover yield were measured and yield per hectare estimated. Panicles were also collected from non-border rows and mean individual weight per panicle determined. The weight of 1000 grains was measured using an electronic balance. (G and G electronic scale, model JJ200 manufactured by Changshu city Shuangjie testing machine company, Jiangsu-China).

2.2.3 Experimental Design and Statistical analysis

The experimental site covered a total area of 6600m^2. Treatments were assigned in a randomized complete block designs (RCBD) and replicated three times. Data collected on soil properties, nutrients and growth and yield of maize was analyzed statistically using Statistix 8 software (Analytical, and Tallahassee, Florida, USA)while differences amongst means of different treatments were separated by least significant difference (LSD)test at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Changes of Soil physical properties

3.1.1 Bulk density, Penetration resistance and Porosity

The impact of soil tillage methods on soil physical properties is shown in fig.2. Highest bulk density recorded under NTTS and NTDS were not significantly different but significantly different from the rest of the treatments for 2016 cropping season. A similar trend was recorded for 2017. However, there was a general drop in soil bulk density in 2017 compared to 2016 among all the treatments due to high rainfall recorded in 2017. Soil bulk density is the significant indicator of change of soil physical health and water retention capacity under different tillage depths (Jin et al 2007). A similar result was reported by Sarwar et al 2008. In New South Wales (NSW), Australia, the soil Bd was reduced by 6.7% in no tillage (at 50 cm depth) compared to conventional tillage after 14 years (He et al 2009. He et al 2009 reported that the mean bulk density (in 0–30 cm soil layer depth) under NT and CT treatments was 1.40 and 1.41 Mg m^{-3}, respectively, and the difference was negligible in the long term which is in agreement with the findings of our study. In Chinese Loess Plateau, crop stubble retention under no tillage and controlled traffic has been reported to increase soil organic matter and biotic activity, thereby reducing bulk density in the surface soil layer (He et al 2009, Franzluebbers 2000). Soil organic C has a direct impact on the bulk density or inversely on the porosity of soil, since the particle density of organic matter is considerably lower than that of mineral soil and soil organic matter is often associated with increased aggregation and permanent pore development as a result of soil biological activity (Brar 2013). The changes in soil bulk density in 0–0.30 m soil layer are consistent with the porosity results. After 8 years of different management, the mean soil bulk density in 2007 was 0.8–1.5% lower in NT than the CT at Daxing and Changping. The reduced bulk density in NT could be attributed to higher organic matter content (Yang 2013) and better aggregation (Rühlmann 2006).

Soil penetration resistance recorded under NTTS and NTDS were not significantly different from one another but significantly different from the rest of the treatments in 2016. Similar trends were recorded in 2017 due to absence of traffic on the land and also natural settling of soil particles from the impact of rainfall and temperature resulting in soil compaction and consolidation. Significant differences were recorded among all the treatments for soil porosity with CT recording the highest. After two years of production, soil porosity did not differ significantly among all the treatments. The lowest soil porosity was recorded under NTTS with 42.63% porosity.

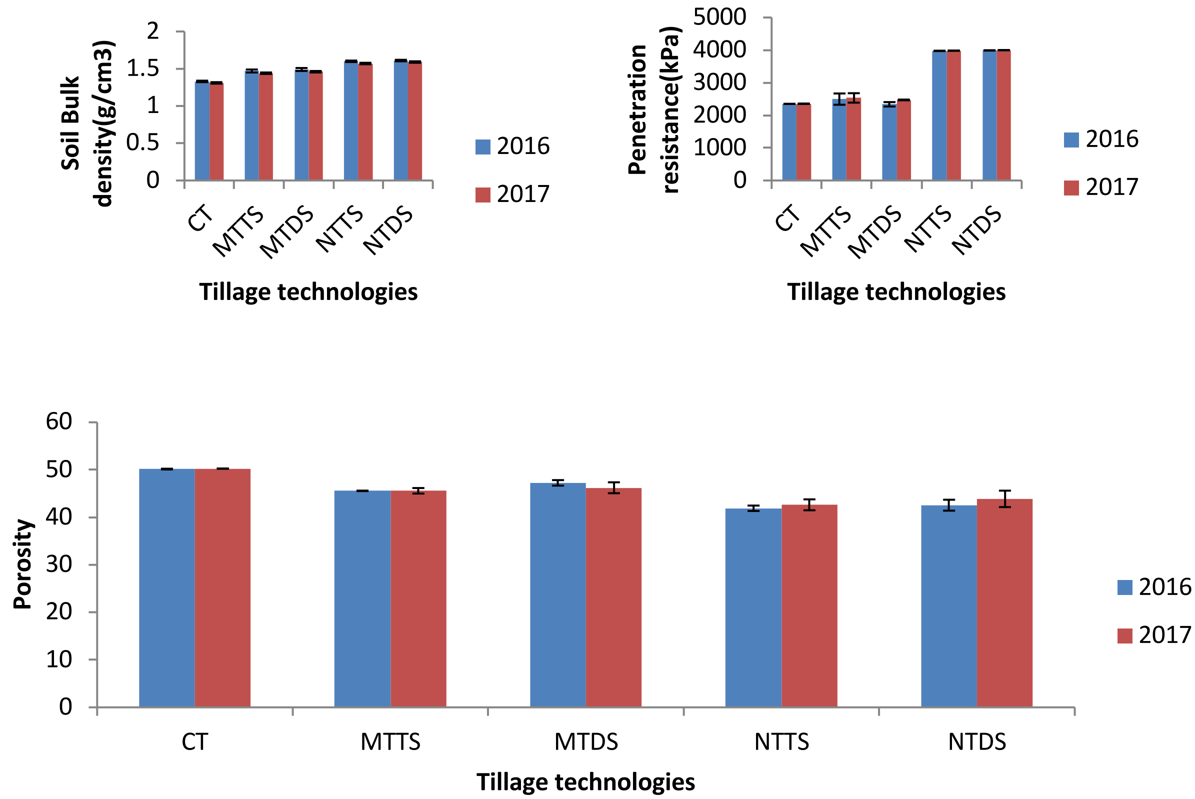


Fig. 2 Effect of tillage methods on soil physical properties in 2016 and 2017

3.2 Soil Chemical properties

3.2.1 Soil pH, Organic Carbon, Available P and N, and Exchangeable K.

There was significant difference ($p \geq 0.05$) in soil pH among all the treatments in 2016(Table 1). Soil pH values recorded were in the order of CT >MTTS >MTDS >NTTS > NTDS with 7.26, 6.99, 6.92, 6.55, and 6.52 respectively. However, in 2017, there was a decline in soil pH among three treatments namely; CT, NTDS and NTTS with 7.11, 6.39 and 6.45 respectively. MTDS AND MTTS recorded and increase in soil pH of 7.00-7.08 respectively. At the end of the study, CT, MTTS and MTDS recorded an increase in soil pH when their respective values were compared to the initial pH value of the soil in 2016 before the introduction of the various treatments. The percentage increase was in the order of CT>MTTS>MTDS with 6.92%, 6.45% and 5.30% respectively. NTDS and NTTS recorded a percentage decrease which was also in the order of NTDS>NTTS with 3.90 and 3.00% respectively. The observation that the surface soil becomes more acidic under NT than under conventional tillage has been previously reported (Limousin and Tessier 2007), the effect being attributed to different processes as the mineralization of organic matter, the nitrification of the surface applied N fertilizer and root exudation.

3.2.2 Soil Organic Carbon

There was no significant difference among all the treatments as far as organic carbon was concern for the 2016 cropping season (Table 1). When compared to the organic carbon in the initial soil sampling, all the treatments recorded a decrease in soil organic carbon. The percentage decrease in organic carbon was in the order of CT>MTTS>MTDS>NTTS>NTDS with 19.09%, 15.21%, 13%, 3.34%, and 5.03% respectively. However, in 2017, only three treatments made up of CT, MTTS and MTDS recorded a decrease in organic carbon with 18.41, 19.92 and 20.46% respectively when compared to the initial soil sampled. NTDS and NTTS recorded an increase in soil organic carbon with 5.58% and 1.65% respectively. There was significant difference ($p \geq 0.05$) in soil organic carbon among all the treatments in 2017. No – tillage has been reported to result in increased soil organic carbon (SOC) content, which in turn enhances soil quality and resilience (Blevin and Frye 1993). The positive effects of RT and MT systems on soil aggregation and SOM contents have been reported for different soil types and climates (Daraghmeh *et al* 2009).

3.2.3 Exchangeable potassium

From the results shown below, NTDS and NTTS had no significant difference between them (Table 1). However, there was significant difference among the rest of the three treatments. The highest K_{aval} of 66.29 mg/kg was recorded by NTDS, followed by NTTDS, MTTS, and NTDS with CT recording the least in the 2016 cropping season. Subsequently in 2017, only NTDS and NTTS recorded an increase in $K_{aval.}$ The percentage increase was 8.22% and 7.15 % respectively for NTDS and NTTS. The least was recorded by CT with 38.03% decrease in available K.

3.2.4 Alkaline nitrogen

All the treatments recorded an in increase in soil alkaline N with the exception of MTDS (Table 1). The percentage increase in alkaline N was in the order of NTTS>CT>NTDS>MTTS with 10.75%, 9.7%, 4.09%. MTDS recorded a percentage decrease of 1.2%. Despite the percentage increase and increase among the various treatments, no significance difference was recorded among the all the treatments. Similarly in 2017, there was no significance difference recorded among all the treatments, though some treatments recorded an increase with other recoding a decrease in alkaline N. the highest alkaline N at the end of the 2017 season was recorded by NTDS with an of 24% when compared to the initial soil sampling value of 10.98 mg/kg. Under the same comparison, the lowest alkaline N was recorded by MTTS with an 8.7% decrease when compared with the initial alkaline N value.

3.2.5 Available phosphorous

Soil available phosphorous did not record any significance difference among the various treatments at the 0-20cm soil depth(Table 1). The highest P_{aval} was recorded by NTDS with 39.51 mg/kg, followed by NTTS with 38.95mg/kg, MTDS with 35.35mg/kg, MTTS with 34.37mg/kg. The least P_{aval} was recorded by CT with 22.50 mg/kg. However in 2017, three of the treatments (CT, MTDS, and MTTS) and two (NTDS AND NTTS) did not record any statistically significance difference. The percentage increase in P_{aval} was in the order of NTDS > NTTS > MTDS > MTTS > CT with 132.98%, 130.87%, 13.55%, and 11.23% respectively. Only CT recorded a 0.59% decrease in $P_{aval.}$

Table 1. Effect of tillage technologies on soil chemical properties in 2016 and 2017

	pH	Org. C ($g\ kg^{-1}$)	Total N ($g\ kg^{-1}$)	Total P (g/kg)	Available K(mg/kg)	Alkaline-N(mg/kg)	Available P (mg/kg)	N (
2016								
CT	7.26±0.09a	20.59±2.12a	1.29±0.03a	0.99±0.04b	41.24±1.17b	12.05±1.77a	22.50±10.352a	1
MTDS	6.99±0.03b	21.58±0.48a	1.66±0.20a	0.73±0.13c	55.70±8.58ab	9.92±2.32a	35.25±6.59a	1
MTTS	6.92±0.03b	22.15±3.34a	1.65±0.35a	1.05± 0.09b	56.070±3.25ab	11.12±1.53a	34.37 ± 11.63a	1
NTDS	6.52±0.01c	24.60±2.53a	1.72±0.21a	1.34±0.04a	66.29 ±1.19a	11.43±0.61a	39.51 ±11.55a	2
NTTS	6.55±0.05c	24.17±1.43a	1.75±0.24a	1.36±0.05a	65.47±10.95a	12.16±2.40a	38.95±9.50a	2
2017								
CT	7.11± 0.02a	18.41±2.11c	1.14±0.01b	0.89±0.05b	39.51 ±1.18c	10.82±1.74a	27.463±3.2838b	1
MTDS	7.08±0.01a	19.92±0.28bc	1.71±0.30ab	0.95 ±0.15b	51.05±4.51b	10.13 ±1.15a	33.917±2.6543ab	1
MTTS	7.00±0.03a	20.46±3.01abc	1.70±0.33ab	0.94±0.08b	51.72±3.60b	10.02±1.49a	33.707 ±5.4055ab	1
NTDS	6.39±0.18b	26.30±1.75a	1.89±0.13a	1.45±0.03a	68.99±1.03a	13.63±1.30a	47.977 ±6.3019a	2
NTTS	6.45±0.09b	25.87±2.11ab	1.75±0.20a	1.43±0.03a	68.31±5.98a	12.83±2.11a	46.620±7.3720a	2

[a]CT: Conventional tillage; MTDS: Minimum tillage direct seeding; MTTS: Minimum tillage Transplanting; NTDS: No tillage direct seeding; NTTS: No tillage transplanting.

[b] For the three treatments, means in each row for a given depth followed by same letters are not different at $p< 0.05$

3.3 Soil nutrient Movement

3.3.1 *NH_4-N distribution along soil profile*

Statistically, there was significance difference among some of the treatments as far as NH_4-N is concern at the depth of 0-20cm (Fig.3). The highest NH_4-N value was recorded by NTDS with 60.10 mg/kg resenting 28.25% followed by NTTS with 59.80

mg/kg representing 27.61%. There was no significant difference between NTDS and NTTS. Subsequently, CT, MTTS and MTDS all recorded a decrease in soil NH_4-N with 24.43%, 15.36% and 18.20% respectively and there was no significance difference among them. Subsequently in 2017, NTDS maintained an increase in NH_4-N with 78.19 representing 66.85% followed by NTTS with 77.48 representing 65.34%. The rest of the treatments maintained a decrease in with CT recording the highest percentage decrease with 33.36mg/kg representing 28.80%, followed by MTDS with 38.11 representing 18.67% and MTTS with 37.33 representing 20.34%. In all, CT, MTDS and MTTS did not record statistical difference among them but each recorded significance difference when compared with NTDS and NTTS. At the depth of 20-40cm, CT recorded the highest amount of NH_4-N (62.95 *mg kg*$^{-1}$) followed by NTTS (55.25 *mg kg*$^{-1}$), MTTS (50.35 *mg kg*$^{-1}$), NTDS (42.63 *mg kg*$^{-1}$). The least NH_4-N was recorded by MTDS (42.07 *mg kg*$^{-1}$). There was however significant difference among all the treatments under consideration. In 2017 however, CT (43.35 *mg kg*$^{-1}$), MTTS (38.11 *mg kg*$^{-1}$) and MTDS (37.66 *mg kg*$^{-1}$) recorded no significant difference among each other. Similarly, no significant difference was recorded between NTTS (82.76 *mg kg*$^{-1}$) and NTDS (79.37 *mg kg*$^{-1}$) but the later two had significant difference with the rest of the treatments. At the depth of 40-60, there was significant difference among all the treatments. CT again recorded the highest NH4-N (49.86 *mg kg*$^{-1}$) followed by MTTS (40.62 *mg kg*$^{-1}$), NTTS (35.11 *mg kg*$^{-1}$), MTDS (34.63 *mg kg*$^{-1}$) with least being NTDS with 25.88 mg/kg. However, in 2017, though there was an increase in NH_4-N among the treatments, there was no significant difference among them. The highest was recorded by CT (66.69 *mg kg*$^{-1}$) and the least was NTDS (49.37 *mg kg*$^{-1}$). At the depth of 60-80cm, significant difference again was recorded among all the treatments with CT (39.433 *mg kg*$^{-1}$) recording the highest NH4-N at a decreasing rate. The least was again recorded under NTDS (22.22 *mg kg*$^{-1}$). This trend was different to the 2017 where there was no significant difference among all the treatments. However, CT (66.89 *mg kg*$^{-1}$) recorded an increase in NH4-N compared to the 2016 cropping season. NTDS recorded the least value of 33.71.At the depth of 80-100cm, CT (33.16 *mg kg*$^{-1}$), MTTS (29.17 *mg kg*$^{-1}$) and MTDS (27.51 *mg kg*$^{-1}$) recorded no significant difference between similar to NTTS (17.86 *mg kg*$^{-1}$) and NTDS (16.20 *mg kg*$^{-1}$) which also recorded no significant difference in 2016. In 2017, there was no significant difference among all the treatments however, CT had the highest NH_4-N(66.89) with the least being recorded by NTDS(63.10 *mg kg*$^{-1}$) The lack of significant difference was consistent from 40-100cm soil depth during the 2017 cropping season.

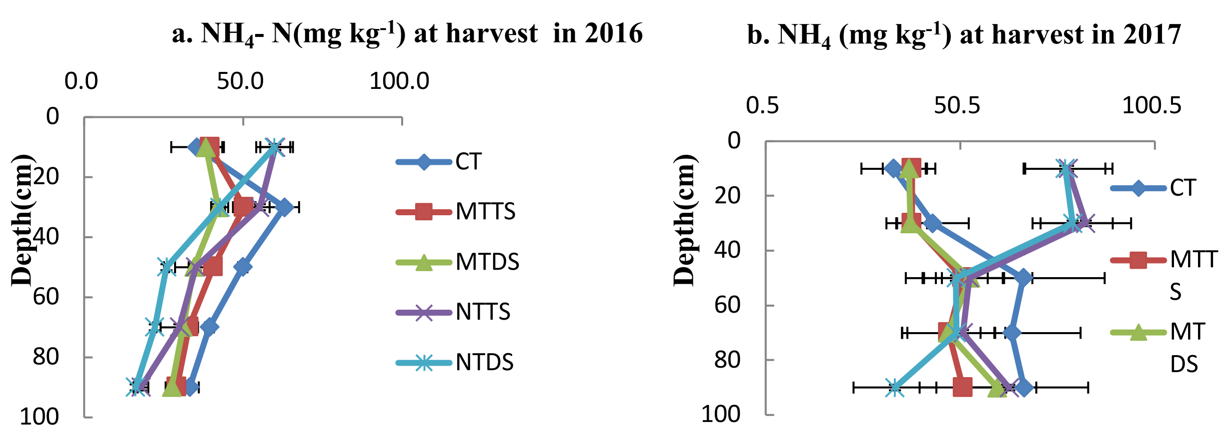


Fig. 3 Effect of tillage methods on NH_4-N in 2016 and 2017

3.3.2 NO_3-N distribution along soil profile

There was significant difference among the various treatments as far soil NO_3-N was concern in 2016 at 0-20cm soil depth (Fig.4). The highest NO_3-N was recorded by NTTS with 27.27% representing a percentage increase of 16.29%, followed by NTDS with 8.99% increase. The other treatments generally recorded a percentage decrease in NO_3-N. The highest percentage decrease in NO3-N was recorded by MTDS with 43.67% followed by CT with 37.31% and MTTS with 36.80%. In 2017, all the treatments except NTDS recorded a decrease in soil NO_3-N. The percentage increase in NO_3-N by NTDS was 16.07%. Moreover, all the treatments did not record any significance difference. Nitrate-nitrogen can easily leach into deep soil, causing nitrogen loss and groundwater pollution (Zhang *et al*., 2004). However, previous studies on the effect of tillage practices on nitrate- nitrogen found different results. Some studies showed that no- tillage for many years in the field increased the number of earthworms in farmland and the number and continuity of large soil pores with good permeability, which caused significant amounts of nitrate nitrogen to leach into deep soil layers (Johnson-Maynard *et al* 2007).

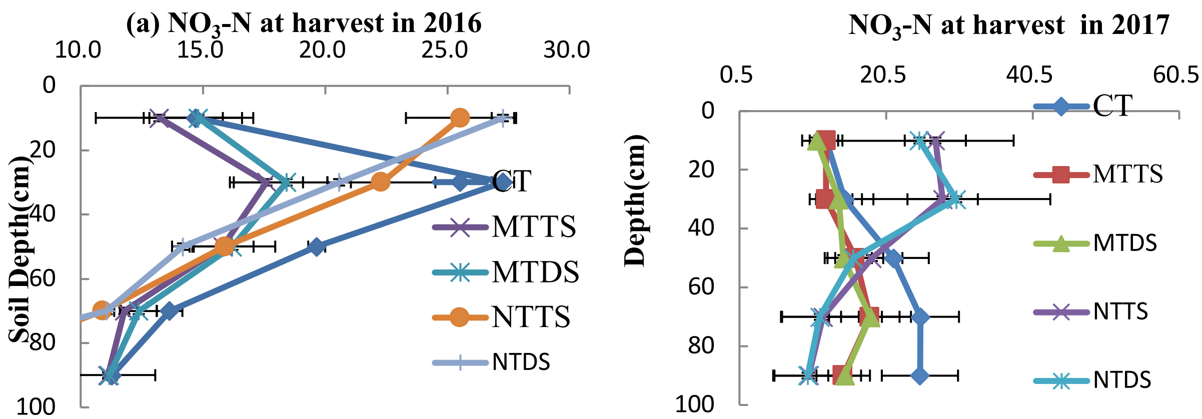


Fig. 4 Effect of tillage methods on NO_3-N in 2016 and 2017

3.3.3 Total P distribution along soil profile

A result from the analysis shows that there was significant difference among all the treatments as far as phosphorous is concern at the soil depth of 0-20cm (Fig 5). NTTS recorded the highest Ptot of 1.36 $mg\ kg^{-1}$, followed by NTDS with 1.34 $mg\ kg^{-1}$, MTTS with 1.05 $mg\ kg^{-1}$, MTDS with 0.73 $mg\ kg^{-1}$ and CT with 0.99 $mg\ kg^{-1}$in 2016. At the end of the study in 2017, NTDS maintained an increase in Ptot. The order of increase of Ptot was NTDS >NTTS> >MTDS >NTTS >CT. However, only CT recorded a percentage drop in Ptot with 29.36%. MTTS recorded a percentage increase of 25.39% followed by MTDS with 24.60%. NTDS and NTTS recorded an increase of 15.08 and 13.49% respectively.

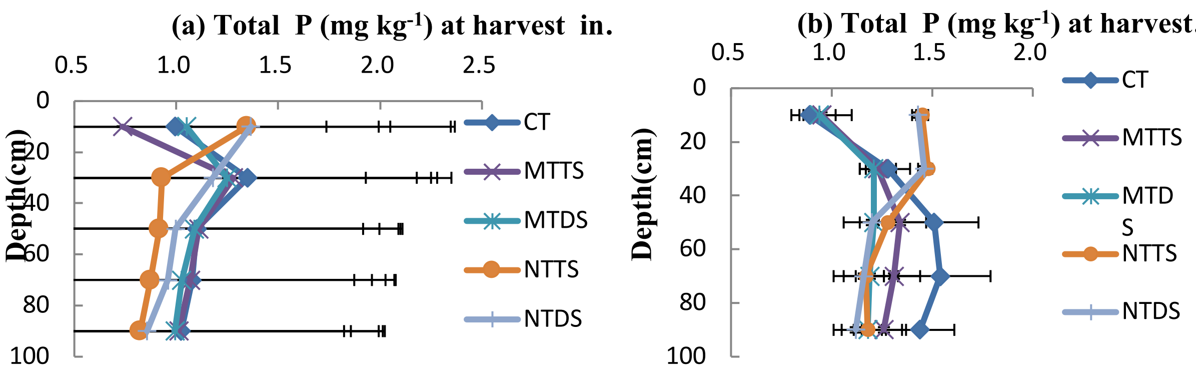


Fig. 5 Effect of tillage methods on Total Phosphorous in 2016 and 2017

3.3.4 Total N distribution along soil profile

Soil total nitrogen did not record any significant difference among the treatment in 2016 at the depth of 0-20cm (Fig 6). NTTS recorded highest total nitrogen of 1.75 g kg^{-1} followed by NTDS with 1.72 g kg^{-1}. This represents an increase in total Nitrogen of 4.79 *mg kg^{-1}* and 2.99 *mg kg^{-1}* respectively for NTTS and NTDS. However, in 2017, there was significant difference among some treatment with the exception of NTDS and NTTS. Highest total nitrogen was recorded by NTDS with 1.89 *mg kg^{-1}* followed by NTTS with 1.75 *mg kg^{-1}* which was not significantly different. However, significant difference was recorded between NTDS and the rest of the treatments and NTTS and the rest of the treatments. Highest percentage decrease in total nitrogen was recorded under CT with1.14 g kg^{-1} representing 31.72%. Thomas *et al* 2007 found no decreases in N_t under NT while N_t under CT decreased in the top-30 cm of soil in a typic Natrsutalf of Australia, managed for nine years under NT.

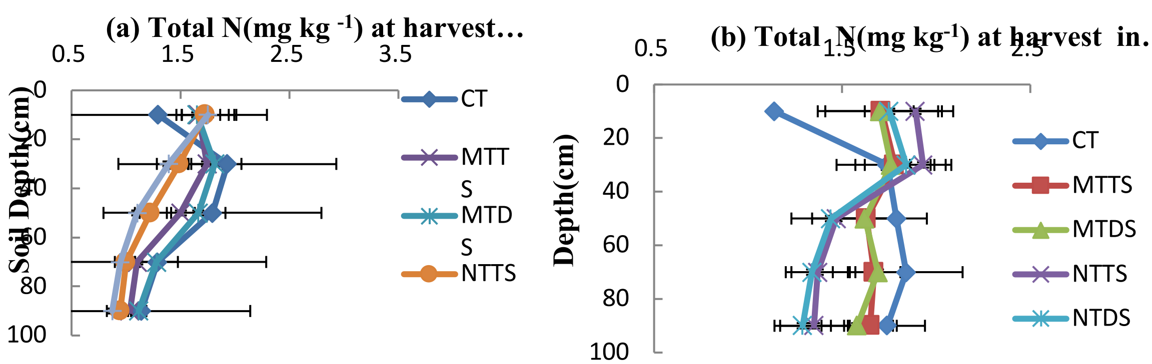


Fig. 6 Effect of tillage methods on Total Nitrogen in 2016 and 2017

3.4 Growth and yield parameters of rice

CT recorded significantly higher plant height for 2016 and the trend was similar in 2017(Table 2). Plant height values ranged from 132.00 to 135.00 in 2016 and 132.00 to 135.00 in 2017.Subsequently, CT recorded highest stover yield in 2016 but the trend changed with NTTS recording the highest stover yield.

The impact of tillage methods on the growth parameters of rice is shown in table 2. The annual grain yield for NTTS was significantly higher than MTDS and NTDS but was not significantly higher that CT and MTTS for the 2016.the yield for 2016 ranged from 5.86 to 6.40 t/ha (Table 2). The trend was similar in the 2017 cropping season with a yield range of 5.90 to 6.60t/ha an improvement of the 2016 yield. However, there was an increase in rice yield in 2017 compared to 2016 as a result of the good interaction between the rainfall, tillage method, nutrients and the season. . A number of field experiments (Soanne *et al* 2012) have studied the response of grain yield to contrasting tillage effects, but the results vary with climatic conditions and soil properties. For example, conservation tillage can improve crop yield in warm-dry climate or well-drained soil (Liu *et al* 2013).

Table 2. Effect of tillage methods on Growth and yield parameters of rice

2016				**2017**		
Treatment	Plant height (cm)	Stover yield(t/ha)	Grain yield (t/ha)	Plant height (cm)	Stover yield (t/ha)	Gr (t/l
CT	135.00±2.39a	5.70±0.10ab	6.30±0.17a	135.00±2.89a	5.70±0.10b	6.6
MTDS	133.00±1.73ab	5.60±0.11b	6.20±0.11ab	133.00±1.73ab	5.53±0.13b	6.1 b
MTTS	134.00±2.31ab	5.63±0.09b	6.30±0.06a	134.00±2.31ab	5.77±0.09ab	6.5 b
NTDS	132.00±1.15b	5.60±0.17b	5.86±0.22b	132.00±1.15b	5.53±0.18b	5.9
NTTS	134.00±1.15ab	5.93±0.14a	6.40±0.11a	134.00±1.15ab	6.03±0.17a	6.6

[a]CT: Conventional tillage; MTDS: Minimum tillage direct seeding; MTTS: Minimum tillage Transplanting; NTDS: No tillage direct seeding; NTTS: No tillage transplanting.

[b] For the three treatments, means in each row for a given depth followed by same letters are not different at $p<0.05$

4. Conclusion

In summary, rice grown in reduced-and no-tillage systems produced grain yields comparable to rice grown in a conventional tillage system under this study. Soil physical and chemical properties, plant height, stover yield and grain yield were all enhanced under the NTTS treatment. The introduction on NTTS saw a reduced movement of soil NH_4-N, $N0_3$-N, total phosphorous and total nitrogen across the soil profile (0-100cm) making it a potential tillage method to reduce agricultural non-point source pollution. Moreover, costs of producing rice in NTTS will be lower than CT, MTTS, and MTDS since no machine is used on the land. Therefore, rice grown in reduced NTTS will have higher net returns than that grown by conventional tillage. Therefore NTTS method in rice farming Ghana could be an effective method in improving soil physical and chemical properties reduce nutrient movement across the profile with a resultant increase in rice yield.

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