TILLAGE MECHANIZATION POTENTIAL EFFECT ON SOIL PHYSICAL PROPERTIES AND GREENHOUSE GAS DISCHARGES.

SHANI, B.B.
Department of Crop and Soil Sciences. National Open University of Nigeria
bshani@noun.edu.ng

ABSTRACT
The study was carried out to investigate the effect of mechanized tillage operations on soil properties and CO_2, CH_4, NO and N_2O Discharges in Maize ((*Zea mays*) research fields. It was conducted from May to November 2019 at National Open University in Kaduna state, Nigeria. The soil of the experimental site is classified as *Eutric Fluvisols* (IUSS Working Group WRB. 2015). A plot of 25m by 40m was isolated in fields planted with Maize (*Zea mays*) and Plot inter-rows were compressed by 1, 2, 3, and 4 cycles a Tractor. Soil samples of different properties and Gas samples (CO_2, CH_4, NO, and N_2O). Discharges were collected and analysed. Results showed that soil volumetric water content (θ_v), bulk density (ρ_b), the pore Tortuosity factor(τ), and Soil Penetration Resistance (SPR) increased while air-filled porosity (f_a), Total Pore Space (TPS) and the soil gas diffusion coefficient (Ds/Do) decreased linearly with increasing Tractor cycle in both Maize ($p< 0.0001$) fields. In Maize field, CO2 ($p< 0.0011$), NO ($p< 0.0257$) and N2O ($p< 0.0116$) Discharges increased quadratically with increasing Tractor cycle. Increasing the Tractor cycle deteriorated soil physical properties and increased greenhouse gas discharges.

KEYWORDS: Tillage, Soil Physical Properties, Greenhouse Air Discharges

INTRODUCTION

Soils variation to resistance to damage could be attributed to the quality of the aggregate rupture. The rupture of peds apart from the human application of engineering materials could be due to clay and clay types, organic matter, polysaccharides, sesquioxides, concentration and presence of varying cementing agents. (Onweremadu, et al., 2021). Farm operations like tillage have exhibited emissions changes of N_2O and the consumption of tends of CH_4 in agricultural soils (Teepe *et al*., 2004).

Derpsch et al., (2010) elaborated on the advantages of Conservation tillage in relation to soil erosion control and water conservation, and zero tillage and how there are globally accepted most especially in dry areas. Nevertheless, Pittelkow et al., (2015) showed that zero-till in mixture with other techniques of conservation agriculture like improved crop rotations and residue management can reduce yields and seemly profitable.

With the purpose of profiting from the usefulness and eliminating the dangers of vigorous herbicide application in normal zero Tillage systems, reduced tillage systems (RT) are visibly improving in the face of organic farming, as expressed by (Mader and Berner, 2012) and further collaborate by (Peigne et al., 2015). The climatic impact of tillage systems is still poorly understood due to limited data availability, but there is much greater information regarding the impacts of ZT compared to TT in traditional farming systems. Therefore, direct impacts of Agricultural management on Global warming include changes in soil organic carbon (SOC) stocks and direct emissions of nitrous oxide (N_2O) and methane (CH_4) from fertilised soils. (Luo *et al*., 2010).

Concerning N_2O in temperate humid climates, researchers such as (Six *et al*., 2004 and Van Kessel *et al*., 2013) have shown that N_2O emissions increase in the starting years after conversion from traditional tillage to Zero Tillage, but reduced in the prevailing ten years.

Furthermore, Rochette (2008) solved the component of soil aeration standing and discovered more N_2O emissions in NT than TT in poorly aerated soils, but not in well aerated soils. Very few studies have been conducted on the effect of various types of tillage systems on CH_4 uptake and Hutsch, (2001) suggests an improvement uptake with conversion to NT/RT management.

Meek, 1994 and Rollerson, (1990) observed that during tillage operations Tractor traffic is amongst the practices that effect the exchange of CO_2, CH_4, NO and N_2O between the soil and the atmosphere subject to the moisture level and soil compaction increase. Preposterously, compaction contains the foundation soil particles (sand, silt, clay) and soil aggregates nearby and substantially change the equilibrium between solids, air-filled and water-filled pore space (Bruand and Cousin, 1995).

Raising the part of water-filled pores, results in making soil compaction susceptible to denitrification and hence higher losses in N_2O losses (Ball *et al*., 2000). However, fewer researchers have been reported on the effect of Tractor compaction on gases Discharges, despite the several studies conducted on the relationship between soil compaction and soil properties, (Rollerson, 1990; Meek, 1994). Within these few studies, Flessa *et al*. (2002) measured N_2O and CH_4Discharges for ridges, un-Compress inter-rows and Tractor-Compress inter-rows from potato (*Solanum tuberosum*) fields. They discovered that

N_2O emissions were topmost for the Tractor Compress soil. But, the greater part of the total CH_4 uptake (+86%) happened on the ridges. Ruser*et al.* (1998) reported that the gaseous Discharges of N_2O and CH_4Discharges from potato field were solidly impacted by ridge-till practices; this birthed portions with raised (ridges) and strongly lessen (Tractor-Compress inter-rows) soil porosity.

Regrettably, the extent of these emissions is not adequately measured as many of these studies are carried out either at the starting, medium or close of the farming season. Nonetheless, in order to correctly estimate the total emissions from agricultural systems, benefaction at every step of farming operations should be determined. The objective of this study was therefore to evaluate the temporary impact of Tractor induced compaction on soil properties and gases discharges in a Maize.

MATERIALS AND METHODS

Experimental Site

This study was conducted at the National Open University of Nigeria, experimental farm 4km off Kaduna- Zaria expressway, Rigachikun, Kaduna state, in the northern guinea savannah zone of Nigeria (altitude; 722 m above sea level, latitude 10.6321^0 N, and longitude 7.4706^0 E from early July to late November 2019. Kaduna State is the third largest city in Nigeria and the temperature typically varies from 55°F to 95°F and is rarely below 50°F or above 102°F. The soils are deep to moderately deep (154 to 183 cm), color ranged from ranged from yellowish red to yellow-brown in surface soils in the range between (1.32 to 1.47g) (2.67 to 2.88gcm3) and (48.94 to 51. 43gcm3) respectively for both surface and subsurface respectively. The soil Ph value is moderately to slightly acidic in both surface (5.5 to 6.1) and subsurface (5.5 to 6.3) horizon organic carbon (0.5 to 1.1%) and total nitrogen (0.1 to 0.2%) are rated low, and available phosphorous was moderate (7.4 to 11.70%). The soils are dominated by exchangeable ca (mean, 3.51cmol (+) kg1), and rated high, followed by Mg 9mean, 1.5cmol (+) kg-1), k (mean, 0.23cmol (+) kg-1), and Na (mean, 0.23cmol (+) kg-1). The soil CEC is lower (12.90%) in surface and slightly higher with increasing depth (18.73%). Field preparation began in May and June, two plots of 40 m long by 25 m width were isolated in fields cropped to maize (Zea mays). These fields were established and maintained by the Department of Crop and Soil Sciences, Faculty of Agricultural Sciences, National Open University. The Maize field was fertilized with N, 130; P_2O5, 180; K_2O, 100 and MgO, 40 kg ha^{-1}. In July 2019, plots inter-rows in Maize fields were Compress by 1, 2, 3 and 4 cycles (1 cycle = 2 passes) with a 2.4 tons Massey Ferguson Tractor (as during regular tillage operations) (Fig. 1). The ridges of crop rows were not Compress. Immediately after Tractor compaction, Soil Penetration Resistance (SPR) was measured to a depth of 100 cm and soil samples were taken in both inter rows and ridges. A second measurement of SPR, sampling for soil properties and greenhouse gas Discharges was conducted three weeks later in August 2019.

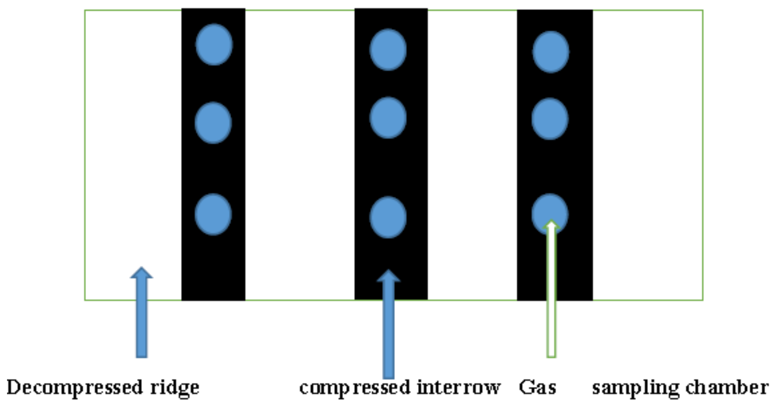

Fig. 1: Experimental site, showing gas sampling chamber, Compress- inter rows and decompress ridges

Determination of Soil Chemical Properties

The analysis of the chemical properties, soil samples were collected at each sampling locations instantly after measurements of greenhouse gases emissions. Soil samples were taken at 10 cm depth from the soil surface with a 6cm height and 4cm diameter aluminium cylinder. The properties studied were soil pH(H_2O and KCl), electrical conductivity (EC), nitrite (NO_2^-), nitrate (NO_3^-) and ammonium(NH_4^+). For analysis of NO_2^- and $NO3^-$, 15 g of field moist soil sample was extracted by 225mL of deionized water (1:5 = soil: water) and concentrations of the above anions were determined by ion exchange chromatography. This extract was also used to measure pH (H_2O) and EC. For NH_4^+ determination, 10g of field moist sample was extracted using 100 mL of 2 M KCl. pH (KCl) was measured using this extract and soil NH_4^+ was determined by calorimetry with indophenol-blue.

Determination of Soil Physical Properties

In the determination of the soil physical properties, soil cores (3 replicates for each of the 5 Tractor cycles) were taken in each of Maize fields at 5 cm depth from the soil surface with a 5 cm diameter and a 6cm height cylinder (volume = 100 cm^3). New Cores weights were first measured then their bottom covered with a filter paper. The filter paper was strongly held with rubbed elastic. On a tension table Cores without their top covers were thereafter transferred and the top of the tension table was covered with a plastic paper to prevent evaporation. Cores were saturated for comparison purpose between calculated Total Pore Space (TPS) to that determined as core volumetric water content at saturation. However, in this report only TPS values calculated were used. After 72 h of saturation, cores fresh weights were again measured and then transferred into an oven to be dried at 105°C for another 72 h. The physical properties such as; Soil bulk density (ρb), Total Pore Space (TPS), volumetric water content (θv), air-filled porosity (fa), relative gas diffusion coefficient (Ds/Do) and the pore tortuosity factor (τ) were later calculated accordingly.

Bulk Density (ρb)

$$\boldsymbol{\rho}_{\boldsymbol{b}=\frac{\boldsymbol{Ms}}{\boldsymbol{Vt}}} \qquad (1)$$

where, ρ_b (kg m^{-3}) is the soil bulk density, Ms (kg) is the mass of dry solids determined after drying the soil sample to constant weight at 105°C and Vt (m^3) is the total volume of soil and thus Vt is the volume of cylinder.

$$Vt = Va + Vw + Vs \qquad (2)$$

where:

V_s (m^3) = Volume of soil solids

V_w (m^3) = Volume of water

V_a (m^3) = Volume of the air fractions successively.

Total Pore Space (TPS)

$$TPS = (Vw + Va+)/Vt \qquad (3)$$

where,

TPS (m^3 m^{-3}) = is the total pore space or the total space of soil filled with fluid (air + water).

V_w (m^3) = Volume of water

V_a (m^3) = Volume of the air fractions successively

Vt = is the volume of cylinder

Gravimetric Water Content (θg)

$$\theta_{g=(Mt-Ms)/Ms} \qquad (4)$$

where:

θ_g(kg soil water kg^{-1} soil) = Gravimetric water content

Ms= mass of the dry soil,

Mt (kg) = Weight of the moist soil sample as taken from the field.

Volumetric Water Content (θv)

$$\theta_{v=\{(Mt-Ms).\rho w\}/Vt} \qquad (5)$$

where:

θ_v (m^3 soil water m^{-3} soil) = Volumetric water content or the volume of water present in a unit volume of the sample.

ρw = Density of water taken as equals to 1000 kg m^{-3}.

Air-Filled Porosity (fa)

$$f_{a=TPS-\theta_V} \qquad (6)$$

where, fa (m^3 soil air m^{-3} soil) is a*ir-filled porosity* or the portion of the pore space filled with air (air space).

Relative Gas Diffusivity (Ds/Do)

Relative gas diffusivity was calculated using Buckinghan (1904) equation:

$$D_s/D_o = (f_a)^2 \qquad (7)$$

where:

D_s/D_o (m^2 sec^{-1}. m^{-2} sec) = Relative gas diffusion coefficient

Ds = Gas diffusion coefficient in the soil (m^3 soil air m^{-1} soil s^{-1})

Do = Gas diffusion coefficient in free air (m^2 air s^{-1}).

Pore Tortuosity (τ)

The pore tortuosity factor was calculated by comparing Reible and Shair (1982).

$$\tau = 1/f_a \qquad (8)$$

where:

τ (m m^{-1}) = Pore tortuosity factor.

Water Filled Pore Space (WFPS)

$$WFPS = (\theta_V/TPS)\,X\,100 \qquad (9)$$

where:

WFPS (%) = Percentage of the total pore space filled with water.

Determination of Gas Discharges

Gases (CO_2, CH_4, NO and N_2O) emissions from Tractor-Compress inter-rows and non-Compress ridges were measured using a closed-chamber technique. This method has also been used by Tokuda and Hayatshu (2000) and (2004). The chambers were circular with steel frames and the top of each chamber had a gas sampling tube and a bag to control air pressure inside the chamber. The height and diameter of the chamber were 0.35 and 0.30 m, respectively. At each sampling time, 3 chambers (each chamber corresponding to a replicate) spaced 15 m were installed in the soil in the inter-row or ridge and kept for 30 min and then samples of the enclosed atmosphere were removed by a 100 mL syringe and transferred into a 1L Tedlar ® Bag with non-sorbant walls. A total of 30 samples (3 replicates x 5 Tractor cycles x 2 fields) were taken in Maize fields. The air temperature inside the chambers was recorded using a digital thermometer. Ambient air between 0 and 2 m from the soil surface was collected and its mean concentration was used as a background concentration for calculation of gas Discharges. Immediately after sampling, a gas chromatography with an electron capture detector and FID used for N_2O and CH_4 analyses, respectively. NO discharge was analyzed by chemo-iluminescence with a nitrogen oxide analyzer (Kimoto, Model 265 P) and an infra-red analyzer was used for CO2. Discharges were calculated using the equation:

$$F = \rho * \frac{V}{A} * \frac{\Delta C}{\Delta t} * \left(\frac{273}{T}\right) * \alpha \qquad (10)$$

where:

F = Gas production rate

P = Gas density (mg m^{-3}) under standard conditions

V (m^3) and A (m^2) = Volume and bottom area of the chamber

$\Delta C/\Delta t$ = Ratio of change in the gas concentration inside the chamber;

T = Absolute temperature

A = Transfer coefficient (12/44 for CO_2, 12/16 for CH_4, 14/30 for NO and 28/44 for N_2O). A positive value reveals gas emission from the soil, while a negative value reveals gas uptake. The detectable limits were 0.1 mg C m^{-2} h^{-1} for CO2, 0.01 µg C m^{-2} h^{-1} for CH_4 and 0.1 µg N m^{-2} h^{-1} for NO and N_2O and the Soil temperature was measured at 5 cm and 10 cm from the top soil layer, using a digital thermometer. The calculation and analysis of summary of simple statistics, analysis of variance, polynomial contrasts, correlation matrix and linear regression was done using the 8.0 statistical package.

RESULTS

Effect of Tractor Cycle on Soil Chemical Properties

Soil chemical properties as affected by Tractor load and cycle are presented in (Table 1). At 5% probability level, Tractor load and cycle did not affect any of the soil chemical properties studied. In magnitude, values of chemical properties observed in ridges were similar to those found in Tractor-Compress inter rows, except for NO3¯ which tended to increase with Tractor cycles.

Table 1: Results of impact of Tillage Operations on Soil Chemical Properties

Tractor cycle	pH (H_20)	pH (KCI)	EC (rnS)	NO_2,$^-$ (mgNkg^{-1}soil)	NO_3^- (mgNkg-^{1}soil)	NH_4^+ (mgNkg-^{1}soil)
Ridge(non-compressed)	7.25	5.82	6.40	0.07	12.24	1.00
Cycle compressed interrows	7.26	5.62	1.10	10.45	1.16	1.07
Cycle compressed interrows	6.93	5.49	7.22	0.05	11.49	1.07
Cycle compressed interrows	7.14	5.60	6.27	0.08	13.78	2.47
Cycle compressed interrows	7.23	5.70	6.22	0.21	10.89	2.10
Analysis of Variance						
Replication	Ns	ns	ns	ns	ns	ns
Cycle	Ns	ns	ns	ns	ns	ns

ns = non-significant difference at LSD = 0.05

Effect of Tractor Cycle on Soil Physical Properties

As can be seen in Table 2 is the result of the relationship between effect of Tractor cycle on soil physical properties. There is significant effect of Tractor cycle on all soil physical properties being studied and there was an increased in Volumetric water content (θ_v), bulk density (ρ_b) and pore tortuosity (τ), while a linear regression analysis showed a decreased in air-filled porosity (f_a), Total Pore Space (TPS) and gas diffusion coefficient (Ds/Do) with a corresponding increase in Tractor cycle. All the Compress interrows, average ridge values for θ_v, ρ_b and τ were lower while those for f_a, TPS and Ds/Do were higher. In addition, in magnitude, values of θv, ρb, τ, fa, TPS and Ds/Do were similar in fields. However, for Tractor-Compress inter-rows, average values of θv, ρb and τ were seen to be higher.

Table 2: The result of the relationship between effect of Tractor cycle on soil physical properties.

Tractor cycle	θ_v (m^3 soil water m^{-3} soil)	ρ_b (kg m^{-3})	fa (m^3 air soil m^{-3})	TPS (m^3 m^{-3})	D_s/D_o (m^2 sec^{-1}. m^{-2} sec)	τ (m m^{-1})
Ridge(non-compressed)	0.34	0.64	0.68	0.91	0.34	1.77
Cycle compressed inter rows	0.43	0.85	0.51	0.76	0.16	2.60
Cycle compressed inter rows	0.49	0.90	0.39	0.66	0.08	3.61
Cycle compressed inter rows	0.40	1.06	0.36	0.61	0.06	4.08

Cycle compressed inter rows	0.55	2.07	0.28	0.60	0.03	6.50
Analysis Of Variance						
Replication	****	****	****	****	****	****
Cycle linear	****	****	****	****	****	****
Cycle Quadratic	****	****	****	****	****	****

Effect of Tractor Load and Number of Cycle On Soil Resistance

The results of relationship of the effect of Tractor load and number of cycle on soil resistance to penetration in July 2019, is revealed in Table 3. Soil resistance to penetration had a linear increased with the Tractor cycle even though the effect was common only in the top 20cm and below of the soil profile while above this depth, the relationship was no longer common. Furthermore, in size, values of soil resistance to penetration measured immediately after compression treatments were double as high in relation to those determined later. Ultimately, in comparison to Tractor-Compress inter rows, SPR values measured on the ridges were less.

Table 3: The results of relationship of the effect of Tractor load and number of cycle on soil resistance to penetration for Maize.

Tractor cycle/Depth	5 <cm	10cm	15cm	20 cm	25cm	30cm
Ridge (non-compressed)	0.24	0.31	0.34	0.36	0.54	1.08
Cycle compressed inter rows	0.68	0.76	0.84	0.26	2.21	2.71
Cycle compressed inter rows	0.72	0.83	0.85	0.87	2.14	2.24
Cycle compressed inter rows	0.87	0.92	0.91	0.96	1.05	2.16
Cycle compressed inter rows	0.88	0.95	0.91	1.03	0.99	2.38
Analysis of Variance						
Replication	ns	ns	ns	*	**	**
Cycle	****	****	****	****	****	**
Cycle linear	****	****	****	****	***	ns
Cycle Quadratic	*	***	***	***	****	ns

*, **, ***, **** significantly different at 5,1,0.1 and 0.01% respectively. ns = not significant

Effect of Tractor Cycle on Greenhouse Gas Discharges

The Tractor load and number of cycle showed a significant correlation regression analysis on all the greenhouse gas Discharges, as presented in Table 4 below;

Table 4: The results of relationship of the effect of Tractor load and number of cycle on greenhouse gas Discharges.

Tractor cycle	CO_2 ($mgCO_2^{-C}m^{-3}h^{-1}$)	CH_4 (µg CH_4-C $m^{-2}h^{-1}$)	NO (µg CH_4-C $m^{-2}h^{-1}$)	N_2O (µg N_2O-N $m^{-2}h^{-1}$)
Ridge (non-compressed)	77.66	-16.29	4.80	88.54
Cycle compressed inter rows	76.65	-28.16	3.28	79.96
Cycle compressed inter rows	96.58	-14.43	10.10	58.07
Cycle compressed inter rows	82.36	-28.38	2.16	88.72
Cycle compressed inter rows	70.39	-16.58	2.05	93.59
Analysis of Variance				
Replication	ns	ns	Ns	ns
Cycle	***	ns	**	*
Cycle linear	ns	-	Ns	**
Cycle Quadratic	***	-	*	**

*, **, *** = significantly different at 5,1,0.1 and 0.01% respectively. ns = not significant

As can be seen in Fig.2, all gas Discharges showed a quadratically regression increased with an increase in Tractor cycle exception of NO Discharges. Although, NO and CH_4 discharges were more in the ridges than Tractor-Compress inter-rows and there was no particular style for the relationship between ridges and Compress inter rows. Discharges in the field. Within the ridges, CO_2 and N_2O Discharges were high and Closer observation of the means also showed in fields, the most CO_2 and N_2O Discharges were gotten after 2 and 4 cycles of inter rows compaction, respectively. The most Discharges for NO were obtained after 2 cycles and CH_4 was consumed in both ridges and Tractor-Compress inter rows.

Analysis of Correlation between Soil Penetration Resistance (SPR) and Greenhouse Gas Discharges

The graph of the regression analysis of the relationship between CO_2 Discharges and soil penetration resistance (SPR) with the measurement at 5 cm and 10 cm depths in the Maize field is presented at (Fig. 2). CO_2Discharges were also significantly correlated with SPR measured at 5 cm ($r = 0.89$, $p = 0.029$) and 10 cm ($r = 0.78$, $p = 0.044$) depth. The CH_4 Discharges were correlated with SPR measured at 5 cm and 10cm depth ($r = 0.56$, $p = 0.014$) and ($r = 0.55$, $p = 0.024$) as shown in Fig, 3. The relationship between N_2O Discharges and SPR measured at both 5cm and 10cm depth (Fig, 4) reveal a that N_2O Discharges were also significantly correlated with SPR ($r = 0.93$, $p = 0.011$) and ($r = 0.93$, $p = 0.045$). At the same depth (5cm and 10 cm), CO_2 was only correlated with SPR ($r = 0.51$, $p = 0.021$) and ($r = 0.33$, $p = 0.032$) respectively.

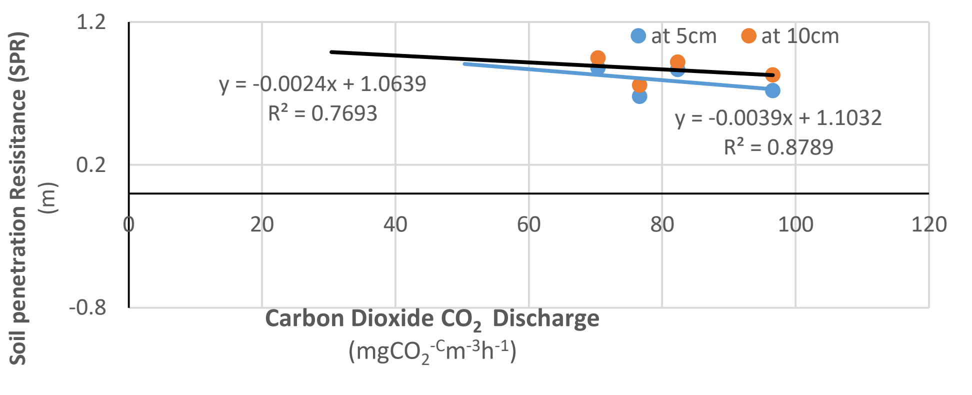

Fig. 2: Graph of Carbon Dioxide CO2 Discharge against Soil...

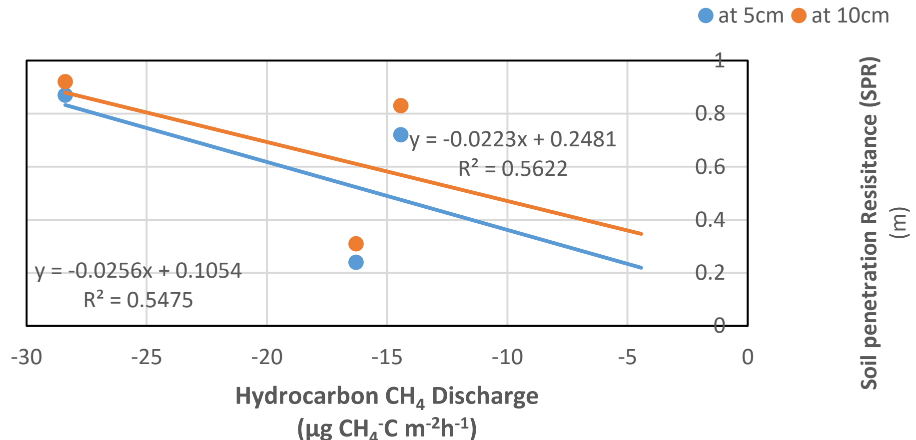

Fig. 3: Graph of HydroCarbon CH_4 Discharge against Soil penetration Resisitance

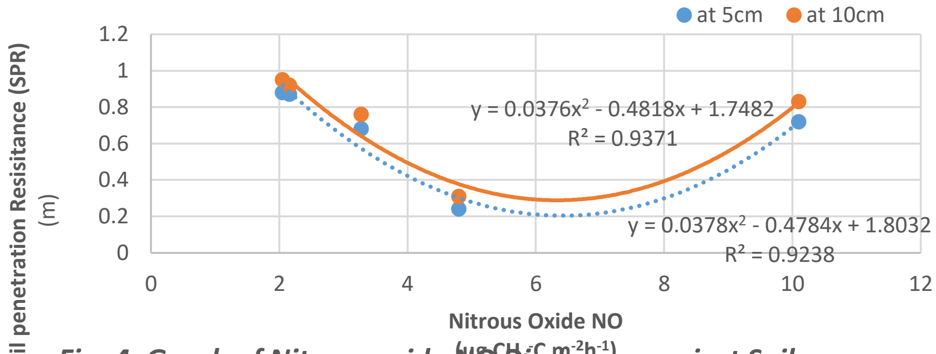

Fig. 4: Graph of Nitrous oxide NO Discharge against Soil penetration Resisitance

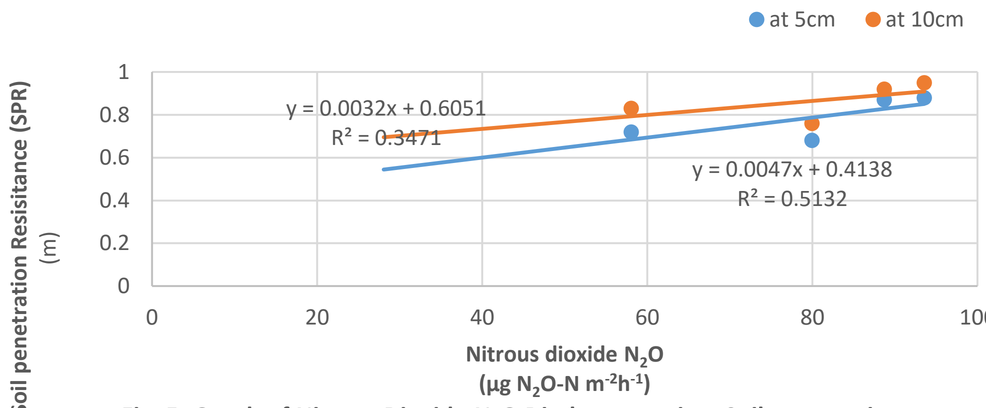

Fig. 5: Graph of Nitrous Dioxide N_2O Discharge against Soil penetration Resisitance

DISCUSSION

In comparison, with the Tractor – compressed inter rows and ridges it was observed that higher average values for bulk density, volumetric water content and pore tortuosity were obtained in Tractor-Compress inter rows. These aligned with what was obtained by Canqui*et al*. (2004), who observed that wheel traffic lessened *K*sat by triple and raised bulk density by 6%. Ginting and Eghball (2005), however, had an opposite result where he observed that wheel traffic had no significant impact on some soil physical properties [(bulk density, soil moisture and water-filled porosity (WFP)] and N_2O Discharges. The lack of difference in bulk density for example in Ginting and Eghball

(2005) study could be due to their depth of soil bulk density measurements (20 cm) as compared to our depth of sampling (5 cm). In fact, it has been suggested that small depth increments might detect bulk density differences that would be obscured in a large depth increment samples (Unger, 1991). Logsdon and Cambardella (2000) indicated that changes in no-till bulk density at the 0- to 12-cm depth was partially due to bio pores from surface feeding earthworms (*Lumbricus terrestris* L.) that were observed in the no-till field but not in the disk field. The air-filled porosity, total pore space and the gas diffusion coefficient were higher in ridges as compared to Tractor-Compress inter rows. These results agree with those of Ruser*et al*. (1998) who reported that ridge-till practice produced areas with increased (ridges) and strongly reduced (inter row soil Compress by Tractor traffic) soil porosity. The air-filled porosity and soil gas diffusion coefficient were lowest and soil penetration resistance of 0-10 cm depth highest in the 4 cycles Tractor-Compress inter rows. This treatment also corresponded to the highest N_2ODischarges in both Maize and Common Bean fields. These results agree with those of Klemedtsson*et al*. (1988) who suggested that the highest N_2O production should occur in the presence of low concentrations of O_2, at the transition between aerobic and anaerobic conditions. Flessa*et al*. (2002) and Ruser*et al*. (1998) also found that soil compaction was an important factor for increased N_2O emissions from ridge tilled potato fields. Teepe*et al*. (2004) reported that high N_2O emissions which occurred after compaction were restricted to short periods at the sandy loam and silty clay loam sites whereas emissions at the silt site remained high throughout the entire growing season. Hansen *et al*. (1993) compared Tractor-Compress and non-retirement Compress soils and found increased N_2O emissions (approximately35%) due to soil compaction. However, emission rates reported by these authors are considerably higher as compared to flux rates measured in the present study. The higher N2ODischarges in these studies can be explained by the much stronger soil compaction (e.g., a bulk density of 1.56 g cm^{-3} for Tractor-Compress soil) and greater WFPS (mean of 85% for Tractor-Compress soil) in Ruser*et al*. (1998) for example. In our study, the highest bulk density observed for the 4 cycles Tractor-Compress inter rows was less than unity and the corresponding WFPS below 65%. In non-Compress ridges, even though the averages air-filled porosity and gas diffusion coefficient were highest, denitrification could still happen, perhaps at a lower level in comparison to Compress soil. However, several studies where soils have acted occasionally as sinks have also been reported. Donoso*et al*. (1993) found that in contrast with a significant emission in the rainy season the soil of a scrub-grass savannah of Venezuela acted as a sink for N_2O in the dry season. All soil physical properties studied were significantly correlated with either CO_2, CH_4, N_2O or NO with correlation coefficients ranging from 0.30 to 0.90. Correlation between soil physical properties and gas Discharges have also been reported by Ball *et al*. (1997) who found significant relationships between N_2ODischarges and air permeability, the soil gas diffusion coefficient and tortuosity. Hu *et al*. (2001) also reported a significant relationship between the soil gas diffusion coefficient and CH_4 Discharges.

CONCLUSION

Tractor compaction increased soil resistance to penetration, water, bulk density and pore tortuosity while reducing air-filled porosity, total pore space and the soil gas diffusion coefficient. Changes in soil physical properties resulted in increased CO_2, NO and N_2O emissions. This work helped identify rarely measured soil physical properties such as D_s/D_o and τ which significantly influenced soil gas exchange. More studies are needed to determine if these effects are permanent or only temporary on both soil and gas Discharges.

ACKNOWLEDGMENTS

The authors wish to thank the Department of Crop and Soil Sciences, Faculty of Agricultural Sciences, National Open University of Nigeria which enabled the atmosphere to conduct this research.

REFERENCES

Ball, B.C., J.P. Parker and G.W. Horgan, 2000. Short-range spatial variation of nitrous oxide Discharges in relation to compaction and straw residues. Eur. J. Soil Sci., 51: 607-616.

Bruand, A. and I. Cousin, 1995. Variation of textural porosity of a clay-loam soil during compaction. Eur. J. Soil Sci., 46: 377-385.

Buckinghan, E., 1904. Contribution to our knowledge of the aeration of soils. U.S Dept. Agric. Bureau Soils Bull., 25: 52-52.

Canqui, H.B., C.J. Gantzer, S.H. Anderson and E.E. Alberts, 2004. Tillage and crop influences on physical properties for an Epiaqualf. Soil Sci. Soc. Am. J., 68:567-576.

Donoso, L., R. Santana and R. Sanhueza, 1993. Seasonal variation of N2ODischarges at a tropical savannah site: Soil consumption of N2O during the dry season.

Flessa, H., R. Ruser, R. Schilling, N. Loftfield, J.C. Munch, E.A. Kaiser and IUSS Working Group WRB. 2015. World Reference Base for Soil Resources 2014, update 2015 International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome,

F. Beese, 2002. N2O and CH_4Discharges in potato fields: Automated measurement, management effects and temporal variation. Geoderma, 105: 307-325.

Ginting, D. and B. Eghball, 2005. Nitrous oxide emission from no-till Irrigated Maize: Temporal fluctuation and wheel traffic effects. Soil Sci. Soc. Am. J., 69:915-924.

Klemedtsson, L., B.J.H. Svensson and T. Rosswall, 1988. A method of selective inhibition to distinguish between nitrification and denitrification as sources of nitrous oxide in soil. Biol. Fert. Soil, 6: 112-119.

Logsdon, S.D. and C.A. Cambardella, 2000. Temporal changes in small depth-incremental soil bulk density. Soil Sci. Soc. Am. J., 64: 710-714.

Meek, F.E., 1994. Effects of skidder traffic on two soils in the Canadian boreal forest. Proceedings of the Interactive Workshop and Seminar FORSITRISK: SoiTree, Machines Interactions, Feldafing, Germany, July 4-8, 1994, Joint FAO/ECE/ILO Committee on Forest Technology, Management and Training, Germany, Switzerland, pp: 1-8.

Rollerson, T.P., 1990. Influence of wide-tire skidder operations on soils. J. For. Eng., 2: 23-30.

Ruser, R., H. Flessa, R. Schilling, H. Steind and F. Beese, 1998. Effects of soil compaction and fertilization on N2O and CH_4Discharges in potato fields. Soil Sci.Soc. Am. J., 62: 1587-1595.

Teepe, R., R. Brumme, F. Beese and B. Ludwig, 2004. Nitrous oxide emission and methane consumption following compaction of forest soils. Soil Sci. Soc.Am. J., 68: 605-611.

Tokuda, S. and M. Hayatshu, 2000. Nitrous oxide production from strongly acid a tea field soils. Soil Sci. Plant Nutr., 46: 835-844.

Tokuda, S. and M. Hayatshu, 2004. Nitrous oxide flux from a tea field amended with large amount of nitrogen fertilizer and soil environmental factors controlling the flux. Soil Sci. Plant Nutr., 50: 365-374.

Unger, P.W., 1991. Overwinter changes in physical properties of no-tillage soil. Soil Sci. Soc. Am. J. 55: 778-782.

Derpsch R., Friedrich T., Kassam A., Li H., 2010. Current status of adoption of no-till farming in the world and some of its main benefits. *Int. J. Agric. Biol. Eng.* 2010; **3:1**–25.

Flessa H., Dörsch P., Beese F., 1995. Seasonal variation of N_2O and CH_4 fluxes in differently managed arable soils in southern Germany. *J. Geophys. Res.* 1995; **100:23115**–23124.

Flessa H., Ruser R., Schilling R., Loftfield N., Munch J.C., Kaiser E.A., Beese F., 2002. N_2O and CH_4 fluxes in potato fields: automated measurement, management effects and temporal variation. *Geoderma.* 2002; **105:307**–325.

Hütsch B.W., 2001. Methane oxidation in non-flooded soils as affected by crop production – invited paper. *Eur. J. Agron.* 2001; **14:237**–260.

Luo Z.K., Wang E.L., Sun O.J., 2010. Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments. *Agric. Ecosyst. Environ.* 2010; **139:224**–231.

Mäder P., Berner A. (2012). Development of reduced tillage systems in organic farming in Europe. *Renew. Agric. Food Syst.* 2012; **27:7**–11.

Onweremadu E.U, Agim L.C, Chukwu E.D, Okoli H.N and Afangide I. (2021). Selected Determinants of Soil Structural Stability in Soil Profile of a Humid Tropical Environment of South Eastern Nigeria. Futo Journal Series (FUTOJNLS)e-ISSN: 2476-8456 p-ISSN: 2467-8325Volume-7, Issue-2, pp50-57

Peigné J., Lefevre V., Vian J., Fleury P.,2015. Conservation agriculture in organic farming: experiences, challenges and opportunities in Europe. In: Farooq M., Siddique K., editors. *Conservation Agriculture.* Springer International Publishing; Switzerland: 2015. pp. 559–578.

Pittelkow C.M., Liang X., Linquist B.A., van Groenigen K.J., Lee J., Lundy M.E., van Gestel N., Six J., Venterea R.T., van Kessel C. 2015. Productivity limits and potentials of the principles of conservation agriculture. *Nature.* 2015; **517:365**–368.

Rochette P. (2008). No-till only increases N_2O emissions in poorly-aerated soils. *Soil Tillage Res.* 2008; **101:97**–100.

Six J., Ogle S.M., Jay breidt F., Conant R.T., Mosier A.R., Paustian K. (2004). The potential to mitigate global warming with no-tillage management is only realized when practised in the long term. *Glob. Change Biol.* 2004; **10:155**–160.

Six J., Frey S.D., Thiet R.K., Batten K.M. (2006). Bacterial and fungal contributions to carbon sequestration in agroecosystems. *Soil Sci. Soc. Am. J.* 2006; **70:555**–569.

Van Kessel C., Venterea R., Six J., Adviento-Borbe M.A., Linquist B., van Groenigen K.J. (2013).Climate, duration, and N placement determine N_2Oemissions in reduced tillage systems: a meta-analysis. *Glob. Change*