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Cover crop biomass and organic manure applications for improved soil physico-chemical properties and tomato yield in a continuous-cropped arable land.

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Abstract

The growing global population and limited land resources have made farmers to rely heavily on continuous cropping, which in turn has negatively impacted soil quality and crop productivity. This study, conducted at location is southwest Nigeria, aimed to restore a continuous-cropped arable land. The study assessed the effectiveness of cover crop biomass and organic manure application on soil physical quality and tomato yield through six treatments in two experiments involving groundnut planting and tomato cultivation. The treatments consisted of piggery manure and groundnut residues (PG+G); poultry manure and groundnut residues (PM+G); groundnut residues only (G only); poultry manure only (PM only); piggery manure only (PM only) and control (no manure). Disturbed and undisturbed soil samples were collected, before the experiment and after the harvest of both groundnut and tomato, from the soil depth 0-40 cm, at 10 cm increments. The results showed that organic amendments significantly ($p < 0.05$) increased soil organic matter by 11-38 % in the 0-10 cm surface layer and 15-36 % in the 10-20 cm subsurface layer while it reduced in the control. The pH increased, soil bulk density decreased by 14-27% (0-10 cm) and 3-27% (10-20 cm), soil water content increased by 12-118% (0-10 cm) and 4-30% (10-20 cm) while the soil saturated hydraulic conductivity improved by 17-218% (0-10 cm). Poultry manure gave the highest tomato yield components: ≈ 224 fruits, ≈ 45 mm fruit diameter, and 15.8 ton/ha yield, all significantly ($p < 0.05$) better than the control and other treatments. These findings showed that cover crops biomass cum organic manure could restore the soil physical quality of continuous-cropped arable lands and significantly optimize crop yield.

Key Words: *Continuous cropping; Cover crop biomass; Organic manure; Soil physicochemical properties; Crop performance*

Introduction

Continuous cropping involved cultivating the same crop variety and closely related ones in the same field for an extended period of time (Tan et al., 2021). Due to increase in population and shortage of land resource to meet food demands, adoption of continuous cropping has gained popularity. For instance, at the end of 2013, China had 1.3 million hectares of arable land, 95% of which was under continuous cropping (Kassam et al., 2014). Continuous cropping practices can have a negative impact on crop productivity and quality, decrease soil water holding capacity, and deteriorate soil hydraulic and physicochemical qualities. Previous researches have shown that continuous cropping could cause a series of issues with the soil, including deterioration of the soil's physicochemical qualities, soil enzyme activity decrease, accumulation of auto-toxic substances, microbial community changes and has alteration in soil physicochemical properties, particularly pH and soil nutrients (Ashworth et al., 2020; Chen et al., 2022; Guo et al., 2022, Yu et al., 2023). According to Mahal et al. (2019) and Majhi et al. (2021), continuous cropping reduces soil nutrients, which is a result of crop absorption and repressed C and N mineralization. This limits material transformation cycling and even affects soil nutrients.
Because human-caused land depletion is not avoidable, the need for land restoration through soil conservation techniques is critical to controlling and sustaining agricultural land. Among the most important soil conservation/land management techniques are the application of organic manure to the soil and growing cover crops (Ntamwira et al., 2023). Cover crop plays an important role in improving soil quality by increasing soil organic matter levels over time with the addition of cover crop biomass (Sainju et al., 2021; Wulanningtyas et al., 2021). The objective of the study therefore was to evaluate the efficacy of cover crop biomass and organic manure applications for improved soil physico-chemical properties and tomato yield in a continuous-cropped arable land in southwest Nigeria.

Materials and Methods

Study site

The study was carried out on the Teaching and Research Farm, Ekiti State University, Ado Ekiti, Southwest Nigeria, located on an elevation of 434 m above sea level, with coordinates ranging from 4°45' to 5°45' E longitude and 7°15' to 8°5' N latitude. The region exhibits a humid tropical climate characterized by a moderate mean annual rainfall (≈ 1,667 mm) and clear distinctions between dry and wet seasons. The temperature remains relatively constant throughout the year, with minimal fluctuation from the average range of 27 °C to 28 °C. The soil in the study site was classified as Typical Kandiudalf (Soil Survey Staff, 2014), with a top sandy-loam to subsoil clay texture (Fasina et al., 2005). The study site has been under continuous cultivation of arable crops for over 10 years with less than six months fallow period before the commencement of this study.

Description of the experiment

There were two experiments; the first experiment involved the imposition of organic manure and planting of groundnut for biomass generation and soil evaluation. The second experiment involved further addition of poultry and piggery manure, incorporation of groundnut biomass and, soil evaluation and tomato performance analysis.

Experimental design, treatments and field layout

The study employed a RCBD (randomized complete block design) of six treatments in three replicates. The treatments consisted of groundnut + piggery manure; groundnut + poultry manure; groundnut only; poultry manure only; piggery manure only and no manure at all as the control. There are three blocks, and in each block, plots measuring 2.5 m x 3 m were laid out as shown in Figure 1 below.

Soil sampling

A mini profile, about 40 cm deep, was dug at the center of each experimental site for soil sampling. Undisturbed soil samples, in three replicates, were collected from soil layers 0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm layers using core samplers, 40 mm high and 57 mm diameter. Disturbed soil samples were also collected from same soil layers. The samples were transported to the laboratory for routine analysis of soil physical and chemical properties. In the laboratory, the disturbed soil samples were air-dried, crushed and sieved to remove materials larger than 2 mm with the aid of 2-mm sieve while the undisturbed samples were trimmed to remove excess soil and oven dried. The samples for soil organic carbon and total nitrogen determination were grounded to pass through a 0.5 mm sieve. The samples were kept in a cool place for further analysis for the soil properties.

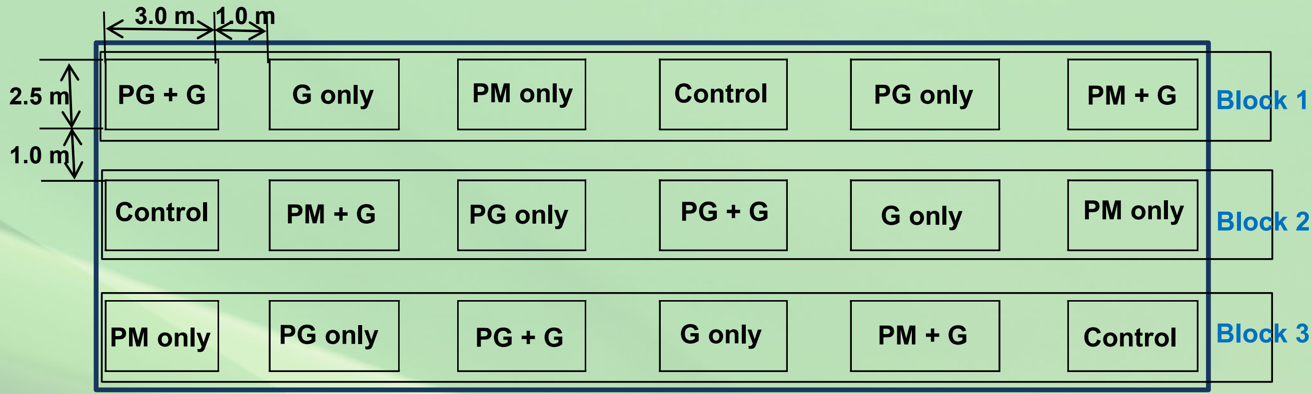

Figure 1: Field layout of the experiment
PG+G: piggery manure and groundnut; G only: groundnut; PM only: poultry manure; PG only: piggery manure; PM+G: poultry manure and groundnut

Laboratory analysis

Soil textural analysis was done using the pipette method (Suzuki et al., 2015), soil particle density was determined using the volumetric flask method (Danielson and Sutherland, 1986) while soil bulk density was evaluated following the methodology described by Blake and Hartge (1986).
Bulk density values were calculated using the following equation:

$$BD = \frac{DM}{V}$$

Where BD is the bulk density (g cm^{-3}), DM is the dry mass (g) of the soil sample, and V is the volume of core sampler (cm^3).

Soil total porosity was obtained from the relation between soil bulk density and particle density (Danielson and Sutherland, 1986). Soil hydraulic conductivity (Ksat, cm h^{-1}) was determined using the constant-head permeameter following the methodology described in EMBRAPA (2011):

$$Ksat = \frac{QL}{A\Delta Ht}$$

Where Q is the volume of water that percolated the soil, cm^3; L is the length of the soil column, cm; A is the cross-sectional area of the core sampler, cm^2; ΔH is the hydraulic head, cm; t is the time of flow in h.

Soil pH was determined in a 1:2 soil water suspension using the digital electrode pH meter, calibrated using buffer solution (Thomas, 1996). Organic matter was quantified using wet oxidation method (Walkley and Black, 1934). A correction factor of 0.39 was used to account for the incomplete combustion of organic carbon. The percent carbon content (OC) of the soil samples was then calculated using the following formula (van Reewijk, 2002).

$$OC, \% = \frac{(ml\ Fe^{2+}\ blank) - (ml\ Fe^{2+}\ soil) x\ Normality\ of\ Fe^{2+}}{Weight\ of\ soil\ in\ g}$$

Tomato yield and yield components

The yield components, including the number of fruits, individual fruit weight (measured in g) were measured and overall fruit yield (metric tons per hectare) was evaluated. Fruit diameter was determined at harvest using a digital vernier caliper, while fruit weight was measured with a precise digital weighing scale during each harvest. The number of fruits was recorded at every harvest session. Fruit yield was calculated by summing all harvested fruits within an experimental unit during the harvest period and was then converted into tons per hectare. The average total yield per hectare was computed by combining both marketable and unmarketable fruit yield, expressed in tons.

Data Analysis

Data collected were subjected to one-way analysis of variance (ANOVA) and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance. Dunnet's test was used to compare the control with other treatments. All statistics were done in SPSS software (SPSS, 2011).

Results

Table 1 presents the physicochemical parameters of the site prior to the commencement of the experiment. The site's initial soil results showed increasing bulk density (1.60–1.76 g/cm³) with depth, exceeding optimal levels for plant growth and indicating compaction. The soil is predominantly sandy which showed poor water and nutrient retention. Saturated hydraulic conductivity (12.8–23.5 cm/h) was highest in the top layer, indicating good infiltration, but field capacity and available water were lowest at the surface (0–10 cm), limiting plant moisture access. Organic matter content was low (1.01–1.86%), below the USDA's 3% standard for healthy soil, and decreased with depth. Soil pH ranged from 5.3 to 6.9 which is suitable for most crops. Total nitrogen was low (0.09–0.11%), indicating a need for nitrogen fertilizer application to support plant growth. The available Phosphorus levels (15.7–16.6 mg/kg) was fairly consistent across soil depths, while exchangeable cations (Na, K, Mg, Ca) and acidity were low. Overall, the soil indicate some degree of compaction, low levels of nitrogen and organic matter content requiring improvements for optimal crop productivity.

Table 2 present the physicochemical properties of the soil after groundnut termination. Soil pH increased at the 0–10 cm depth across all treatments compared to pre-experiment data, with minimal variation among treatments and depths. Organic matter (OM) in the surface layer increased by 13–213% due to groundnut cover and organic manure, highest in Poultry Manure (PM) only and lowest in the control. OM generally declined with depth, except in the G only treatment. Surface OM followed the order: PM only > PG+G > PM+G > PG only > G only > Control, a trend also observed in subsurface layers. Bulk density (BD) at 0–10 cm decreased by 7–13% in all treatments except PG only, with PG only and control having the highest BD. Compared to pre-experiment values, surface BD ranked: PG only = Control > G only > PM only > PM+G > PG+G. Subsurface BD increased inconsistently across treatments. Saturated hydraulic conductivity (Ksat) increased by 9–476%, peaking in the PM+G treatment, and declined with depth. Soil water content (SWC) increased by 4–63% at the surface, highest in PM+G and PG+G, and lowest in G only.

For the 0-10 cm surface layer, the control had the highest pH value and showed a significant difference ($p < 0.05$) when compared to other treatments and increased in the order of Cont > PM only > G only > PG only > PM+G = PG+G. For the subsurface layers, there was no significant difference ($p > 0.05$) in pH due to the organic amendments (Figure 4.2a). In contrast, notable variations in soil organic matter content were observed across the different treatments and the two soil layers evaluated.

Apart from control, applying various soil amendments led to a statistically significant ($p < 0.05$) rise in soil organic matter (SOM) in both soil layers with treatment PG+G and Control having the highest and lowest SOM, respectively in both soil layers. The SOM was in the order of PG+G > G only = PM only > PG only > PM+G > Control.

Table 1. Measured some soil physical, hydraulic and chemical properties of the experimental site before the experiment.

Soil chemical properties									
Soil depth	pH_{H2O}	OM	TN	A.P	Na	K	Mg	Ca	EA
cm	-	%	g/kg	mg/kg	-------------cmol/kg-------------			-	
0-10	5.3	1.86	0.11	15.7	0.09	0.79	1.15	3.25	1.35
10-20	6.9	1.55	0.09	16.6	0.06	0.43	1.00	2.75	0.83
20-30	6.5	1.16	0.10	13.4	0.09	0.48	0.90	2.80	0.83
30-40	6.4	1.01	0.09	11.1	0.09	0.54	0.85	2.65	0.88
Limit	6.0-7.5*	3-5**							

Soil physical and hydraulic properties							
Soil depth	BD	Ksat	SWC	Sand	Clay	Silt	Texture
cm	g/cm^3	$cm\ h^{-1}$	g/g	------------%------------			
0-10	1.60	23.5	0.104	78.6	10.9	10.5	SL
10-20	1.68	14.2	0.103	76.9	10.4	12.8	SL
20-30	1.74	16.4	0.126	74.4	12.3	13.4	SL
30-40	1.76	12.8	0.147	67.7	23.6	8.7	SCL
Limit	0.9-1.2**	1.8-18**	>0.200**	-	-	-	-

*FAO (2021); **Reynolds et al. (2015); OM: organic matter; TN: total nitrogen: A.P: available phosphorus; Na: sodium; K: potassium; Mg: magnesium; Ca: calcium; EA: exchangeable acidity; BD: bulk density; Ksat: saturated hydraulic conductivity; SWC: soil water content; SL: sandy loam; SCL: sandy clay loam

Table 2: Measured physical and hydraulic properties of the experimental site after termination of groundnut.

	PG+G	Cont	PM only	G only	PM+G	PG only
Soil depth, cm	pH					
0-10	6.8	6.8	6.9	6.9	6.9	6.8
10-20	6.8	6.7	6.9	6.9	6.9	6.9
20-30	6.8	6.8	6.8	6.8	6.9	6.9
30-40	6.8	6.8	6.8	6.9	6.9	6.9
	OM, %					
0-10	3.9ab	1.6c	5.0a	1.8c	2.9b	2.4bc
10-20	2.4	1.5	3.4	2.4	2.9	2.5
20-30	2.0	1.4	2.9	1.8	2.7	2.2
30-40	1.9	1.5	2.2	1.6	2.7	1.2
	Bulk Density, $g\ cm^{-3}$					
0-10	1.3	1.5	1.3	1.4	1.3	1.5
10-20	1.4	1.6	1.6	1.5	1.6	1.6
20-30	1.4	1.6	1.6	1.6	1.6	1.7
30-40	1.7	1.6	1.7	1.6	1.7	1.9
	Ksat, $cm\ h^{-1}$					
0-10	144.7b	39.7e	60.8d	43.4e	228.5a	84.5c
10-20	36.7	12.4	43.9	18.6	127.9	69.7
20-30	5.3	17.6	68.7	59.3	189.6	96.6
30-40	2.8	33.5	49.0	66.6	95.1	33.1
	SWC, %					
0-10	23.6a	14.5b	15.1b	14.4b	23.6a	12.9b
10-20	16.5	12.7	12.6	13.9	12.8	11.8
20-30	10.7	11.3	10.2	11.0	11.3	11.5
30-40	18.0	12.5	12.3	10.6	14.2	12.7

PG+G: piggery manure and groundnut; G only: groundnut; PM only: poultry manure; PG only: piggery manure; PM+G: poultry manure and groundnut, OM: organic matter; BD: bulk density; Ksat: saturated hydraulic conductivity; SWC: soil water content

The soil BD, aggregate stability index (ASI), Ksat, and SWC of the different soil layers after tomato harvest are presented in figüre 3. The BD differed significantly ($p < 0.05$) in all the soil layers as a result of groundnut cover crop biomass and organic manure addition. At the 0-10 cm surface layer, BD was highest in the treatment G only and lowest in the treatment PG+G while at other layers, the Control had the highest BD. For the 10 - 20 and 20 - 30 cm subsurface layers, the Control had the significantly ($p < 0.05$) highest BD compared to other treatments. For the 30-40 cm layer, the BD was significantly ($p < 0.05$) higher from the Control, G only and PM than other treatments. The ASI was significantly influenced ($p < 0.05$) by groundnut cover crop biomass and organic manure addition only at the 0 - 10 and 10 - 20 cm soil layers. In the 0 - 10 cm surface layer, the Control had the highest ASI but this did not differ ($p > 0.05$) from those of treatments PM+G and PG+G. At the 10 - 20 cm, the Control and treatments G only and PG+G had higher ($p < 0.05$) ASI compared to others.

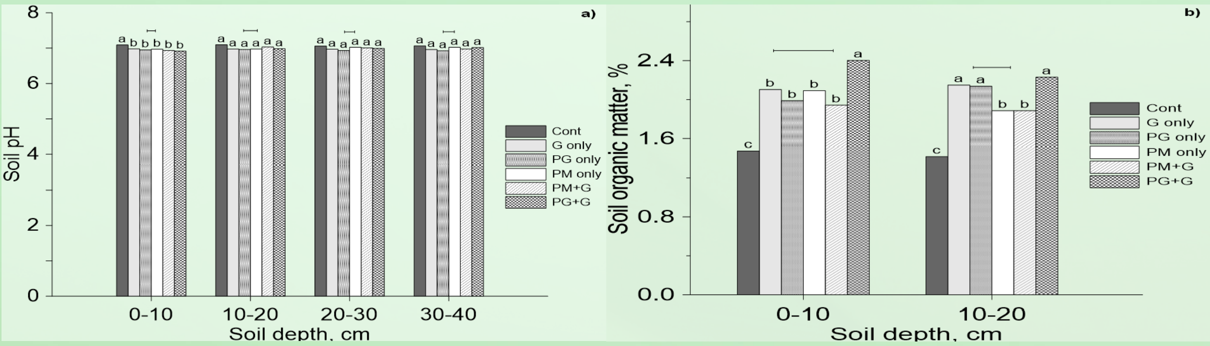

Figure 2. a) pH and b) matter content of the different soil layers after harvest of tomato.
PG+G: Piggery manure and groundnut biomass; PM: Poultry manure only; G: groundnut only; PM+G: Piggery manure and groundnut biomass; PG: Piggery manure only; Cont: Control; The horizontal bars are the standard error of the mean; Vertical bars with different letters differed significantly at 5% level of probability by Duncan Multiple Range test.

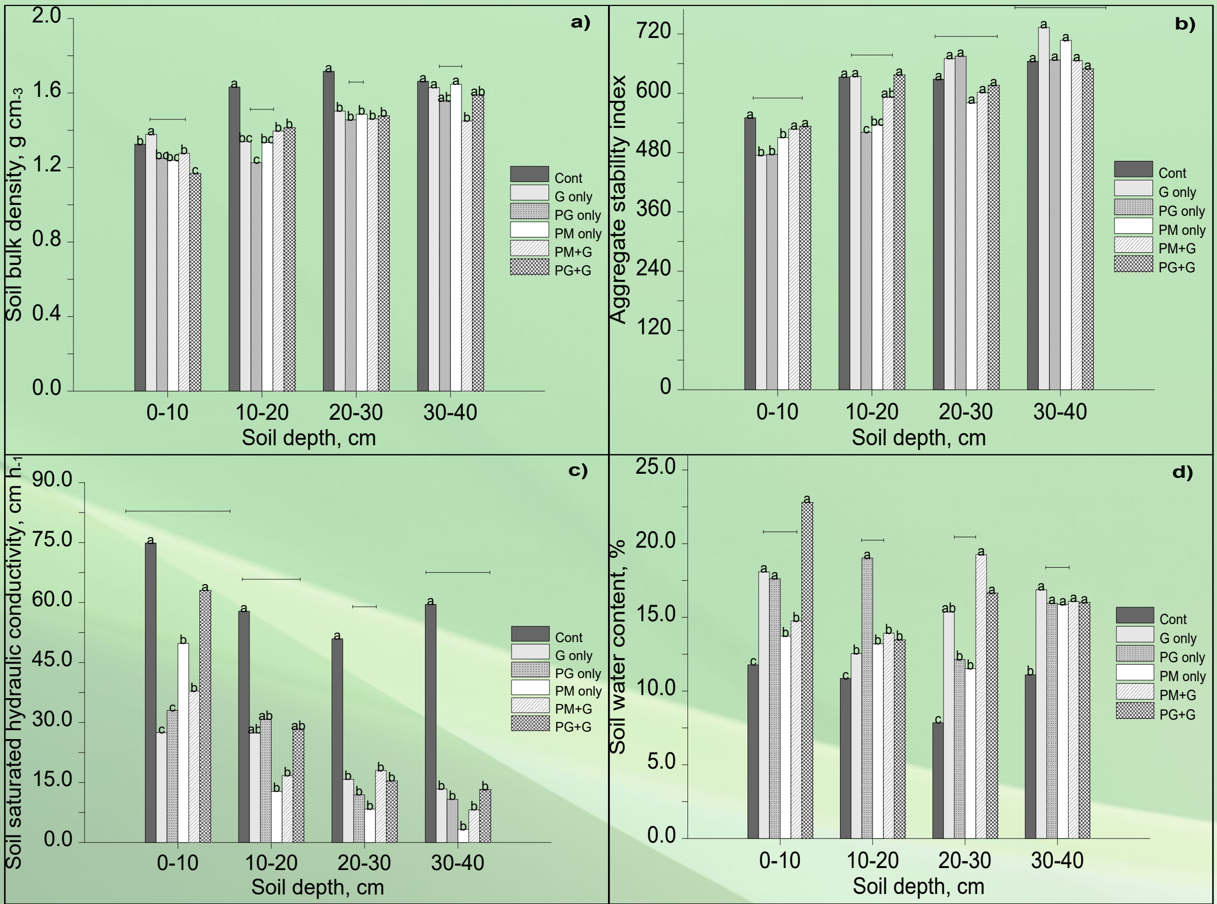

Figure 3. a) bulk density, b) aggregate stability index, c) saturated hydraulic conductivity, and d) water content of the different soil layers after harvest of tomato.
PG+G: Piggery manure and groundnut biomass; PM: Poultry manure only; G: groundnut only; PM+G: Piggery manure and groundnut biomass; PG: Piggery manure only; Cont: Control; The horizontal bars are the standard error of the mean Vertical bars with different letters differed significantly at 5% level of probability by Duncan Multiple Range test.

Table 3 shows the data on the yield as well as the yield components of the tomato crop under different soil amendments. The use of soil amendments was observed to have a significant ($p < 0.05$) effect on both the quantity of fruit produced and the overall yield. The plot treated with a combination of PG+G resulted in the maximum fruit yield, whereas the plots treated with G only and the control had the minimum fruit yield. Nevertheless, except from the control and the G only, no statistically significant differences ($p > 0.05$) were seen among the remaining treatments. Furthermore, it was observed that the PM treatment had the biggest fruit diameter whereas the G treatment displayed the smallest fruit diameter. In addition to the PG only and PG+G treatments, statistically significant differences ($p < 0.05$) were seen across the remaining treatment groups. The results of the study revealed a statistically significant ($p< 0.05$) impact of soil amendments on tomato yield. The plots treated with a combination of PG+G, PM+G, PM, and PG gave similar yield, which were considerably distinct ($p < 0.05$) from those of the treatment with G only and control. When compared to the control, the poultry treatment exhibited the most notable outcomes in terms of tomato fruit quantity (about 224 fruits), fruit diameter (approximately 45 mm), and yield (15.8 ton/ha).

Table 3. Yield and yield components of the tomato crop under different soil amendments.

Treatments	Number of Fruits	Fruit Diameter, cm	Yield, ton\ha
Control	170.3b	43.1abc	12.2b
G only	159.0b	40.9c	10.2c
PG only	210.0a	43.7ab	13.8a
PM only	223.3a	44.8a	15.8a
PM+G	207.0a	43.9ab	14.1a
PG+G	230.3a	42.3bc	15.0a
SEM	45.49	0.73	3.45

PG+G: Piggery manure and groundnut biomass; PM: Poultry manure only; G: groundnut only; PM+G: Piggery manure and groundnut biomass; PG: Piggery manure only; Cont: Control
SEM: standard error of the mean
Columns with different letters differed significantly at 5% level of probability by Duncan Multiple Range Test (DMRT)

Discussion

Initial soil conditions

The pH of the 0-10 cm surface layer was outside the range (below the lower limit) while those of the subsurface layers were within the range considered acceptable for most plants according to FAO standard operating procedure for soil pH determination (FAO, 2021). The organic matter content is generally low and decreased with soil depth. Fertile soil is soil that has been supplemented with nutrients. A fertile soil may be inherent or natural, and manures or artificial fertilizers can be used to get it (Ansa et al., 2022). Physical, chemical, or biological elements may have impacts on soil fertility, which in turn may have effects on plant growth. Plants cannot absorb nutrients like nitrogen, phosphorus, sulfur, and carbon as they are; instead, they must be transformed by microorganisms through nutrient cycling into their normal forms. The soil bulk density (BD) is high and increased with soil depth. The optimal BD for most soil textures should be in the range of $0.9 \leq BD \leq 1.20$ g cm^{-3} (Reynolds et al., 2015). For this site, the BD was well above the range, indicating denser soil. Furthermore, the higher BD observed 20-30 cm and 30-40 cm subsurface layers are close to the range 1.75–1.85 g cm^{-3} considered restrictive soil condition which could impair water and air movement, root morphology and crop development (Reichert et al., 2018). The 0-10 cm surface layer had Ksat above the 18 cm h^{-1} designated as the upper optimal limit for humid climates, indicating susceptibility to doughtiness and nutrient leaching while the subsurface layers had Ksat within the optimal range ($1.8 \leq Ksat \leq 18.0$ cm h^{-1}) for crop essential water and drainage of excess water. The 0-10 cm and 10-20 cm layers had SWC below ideal for adequate root growth and drought resilience (Reynolds et al., 2015) while the higher SWC in the subsurface layers is attributed to the higher clay content (Table 1). The total nitrogen values were between 0.09 and 0.11 g kg^{-1}, while the available phosphorus had values between 11.1 and 16.6 mg kg^{-1}. The exchangeable bases (Na, Mg, K and Ca) and exchangeable acidity were highest in the 0-10 cm surface layer.

Soil conditions after the first experiment (planting of groundnut cum addition of organic manure)

The soil pH was at par across different treatments and depths, ranging from 6.7 to 6.9. This stability suggests that the treatments applied do not significantly impact the soil acidity, which is essential for nutrient availability and microbial activity (Brady and Weil, 2008). The soil organic matter content of the 0-10 cm surface layer increased between about 13 and 213% due to groundnut cover crop and organic manure addition compared to the control, with the PM only treatment having the highest organic matter content, indicating its potential in improving soil fertility (Lal, 2024).

For the 0-10 cm surface layer, except the PG treatment, the BD decreased between 7 and 13% due to groundnut cover crop and organic manure application compared to the control, with the highest observed in the treatment PG only and control. The lower BD values in PG+G, PM, PM+G suggest improved soil structure. Compared to the pre-experiment soil conditions, the BD had decreased on the surface soil in the order PG only = Control > G only > PM only > PM+G >PG+G. For the subsurface layers, the BD increased but without any discernible trend among the treatments. Ksat of the 0-10 cm surface layer increased between 9 and 476% due to groundnut cover crop and organic manure application, with the PM+G treatment having an exceptionally high Ksat compared to other treatments. The higher Ksat observed in the plots with groundnut cover crop and organic manure indicates increased drainage these treatments (Saxton and Rawls, 2006). Similarly, the SWC of the 0-10 cm surface layer increased between 4 and 63% due to groundnut cover crop and organic manure application compared to the control. The higher SWC in the treatments suggests better water retention (Vereecken et al., 2010).

Soil conditions after harvest of tomato

At the harvest of tomato, the soil pH of the 0-10 cm surface layer had increased between about 31% in all treatments including the Control compared to pre-experiment data. For the subsurface layers, groundnut cover crop biomass and organic manure addition did not influence ($p > 0.05$) the soil pH. While the pH was almost at par in the 10-20 cm soil layer, it slightly increased by about 8% in the 20-30 and 30-40 cm deeper layers at harvest of tomato.

Soil organic matter content was significantly ($p < 0.05$) affected by groundnut cover crop biomass and organic manure addition in both soil layers, with the control having the lowest values. Compare to pre-experiment condition, SOM had increased between 4.4 and 29.2% with the trend PG+G > G only > PM only > PG only > PM+G while it decreased by about 21% in the control at the 0-10 cm surface layer. Similar trend was observed for the 10-20 cm subsurface layer. Cover crops have also been reported to increase soil organic matter by 7-12% compared to no cover crop management (Hu et al., 2023; Peng et al.,2023) and this can lead to improved soil aggregate formation and increased water infiltration (Arel et al., 2022, Shen et al., 2021) Therefore, it can be said that organic manures are beneficial sources of nutrients in addition to improving the physical environment of the soil. Similar results were showed (Dhaliwal et al., 2023, Goldan et al., 2023, Köninger et al., 2021). The highest organic carbon content was noticed with the application of piggery manure and groundnut (2.4%). Nevertheless, application of nutrients in organic form would improve the crop growth and leaves behind several residues including crop root. Perhaps, slow mineralization could lead to organic carbon accumulation in soil.

The soil BD, aggregate stability index (ASI), Ksat and SWC of the different soil layers after tomato harvest are presented in figure 3. The BD differed significantly ($p < 0.05$) in all the soil layers as a result of groundnut cover crop biomass and organic manure addition. For the 0-10 cm surface layer, BD was highest in the treatment G only and lowest in the treatment PG+G. Compared to the pre-experiment soil conditions, the BD had decreased between 13.8 and 27.0% even in the control in the order PG+G > PM only > PG only > PM+G > Control > G only. For the subsurface layers, the BD also decreased but without any discernible trend among the treatments (Figure 3a). The ASI was significantly influenced ($p < 0.05$) by groundnut cover crop biomass and organic manure addition only at the 0-10 and 10-20 cm layers, with the Control having the highest ASI but this did not differ from those of treatments G only, PM+G and PG+G.

In addition, the ASI had decreased by 7.4% in treatment PG+G and 17.6% in treatment G only compared to the about 4% reduction in the Control (Figure 3b).

Soil Ksat was significantly highest ($p > 0.05$) in the Control compared to other treatments for all the soil layers evaluated, with the treatment G only having the lowest Ksat at the 0-10 cm surface layer. For other layers, the trend observed in the surface layer was not followed. Compared to the pre-experiment data, Ksat increased between 17% (treatment G only) and 218% (Control) in the 0-10 cm surface layer. For the subsurface layers, the Ksat either increased or decreased (Figure 3c).

At harvest of tomato, the SWC of the 0-10 cm surface layer was significantly lowest ($p < 0.05$) in the Control and highest in the treatment PG+G compared to other treatments. For subsurface layers, the Control also had the significantly lowest SWC while there was no discernible trend among the treatments. The SWC had also increased between 31.6% (PM only) and 118.6% (PG+G) compared to the 12.9% increase observed in the Control (Figure 3d).

Tomato yield and yield components

Except for the treatment G only, the number of fruits was higher between 21 and 35% for the soil amendment treatments than the control, with the highest increase obtained from the treatment PG+G. For the fruit diameter, the treatments PG only, PM only and PM+G treatments had tomato fruits bigger than the control by 1.4, 3.9 and 1.9%, respectively. The highest tomato yield was observed in treatment with PM only but did not statistically differ from those of the treatments PM+G, PG+G, and PG only while the treatment G only had the lowest yield. Furthermore, the treatments PG only, PM only, PM+G and PG+G had yield higher than the control by 13, 30, 16 and 23%, respectively. The notable enhancement in tomato yields can be mainly attributed to the stabilization of soil structure. This stabilization has led to a decrease in soil bulk density, an increase in porosity, improved infiltration rates, and enhanced water retention capacity. These beneficial changes in soil physics are the key factors behind the significant boost in tomato production observed in the plots where these amendments were applied. These findings are consistent with previous studies (Downie et al., 2009; Stewart-Wade, 2020). Previous research highlighted the substantial impact of cover crops and organic amendments on tomato yield when compared to the control (Wang et al., 2018).

Conclusion

The study demonstrated that using cover crops and organic manures significantly enhances soil quality, which in turn leads to increased tomato yield. These organic amendments improved soil physical properties by reducing bulk density and increasing hydraulic water content, water retention, and available water. This ensures better soil water dynamics, supporting plant growth during critical periods. Also, the amendments increased soil pH and raised organic matter content, further contributing to soil fertility and productivity. Overall, organic manure and cover crops positively influenced both growth and yield components of tomato, suggesting that degraded arable land can be restored through sustainable practices. Based on these findings, the study recommends that farmers in Ekiti State adopt soil amendments, particularly poultry and piggery manure, either alone or combined with groundnut, to improve tomato production and promote sustainable agriculture.

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